WET

Water Education for Teachers

Project WET Montana

PROJECT WET MONTANA

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1991

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Presented by

Project WET Montana

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Affiliation

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AN INCREDIBLE JOURNEY

Objectives: Students will be able to:

1. comprehend the age of water,
2. understand the recyclable nature of water, and
3. discuss the importance of water management to protect our "old friend" water.

Background

How old is the earth's water? How old is Montana's water? The earth's water and Montana's water is as old as the earth itself or, in other words, the earth's water has been around since the beginning of time. Further, the water that we drink, sprinkle on crops, fish in, and use to manufacture goods today, is the same water that was on the earth from the beginning of time. The only difference is the water is much older. Another important fact is the earth has the same amount of water today as it had millions years ago - no more, no less.

Does this mean that prehistoric dinosaurs could have drank the same water that we drink today? That a remote tribe in the rain forest of Africa might have used to wash their wild game? Or the water that was flushed down a toilet in New York? Or the water that Columbus sailed on to reach America? You might be surprised that the answer to these questions is yes. Even after being used time and time again by people, domestic animals, fish and wildlife, plants, bacteria, and all other forms of life, most of the earth's water is still potable (drinkable).

What does this say about water? First of all, it says water is recyclable. Water has a remarkable ability to return to a useable state after being used. As water moves through the hydrologic cycle or water cycle it is filtered by underground soil and rock material, it is evaporated off lakes and streams, and it is taken up by plants through process called evapotranspiration and sent into the atmosphere as water vapor leaving contaminants behind. The quality of Earth's water would degrade at a rapid rate in the absence of these important natural processes. People also play a role in cleaning water. For example, although it's not a most pleasant thought to think that you might be drinking the water that passed through a person into a waste water treatment plant and then into a river, however, this could happen. Why don't you get sick? Fortunately, waste treatment and water purification technology has advance to the point that most common contaminants can be removed before being delivered to users.

Materials

* Clear glass or water bottle filled with water

* Paper, pencils, and coloring pens or pencils

Activity

This activity is simple and effective. The goal is to help your students to comprehend the age of water. This can be accomplished in the following manner:

1. Ask your students to look at the water in the bottle you are holding and guess its age. Pass the bottle around the room to give them a closer look. Allow a few minutes for guesses. After a few minutes of discussion, tell your students that the water is as old as the earth itself. Some scientists think the earth's water could be 4 billion years old.

2. Now ask your students to look at the water and think about the journey the water has been on. You might want to provide an example of a hypothetical journey. After your students comprehend how old the water in the bottle is, have each student write "An Incredible Journey" story about the water. Have your students pretend that they are a molecule of water. Each student should write a hypothetical story about were they have been. You should encourage your students to draw pictures depicting the time and the events describe in the story.

Closure

Have each student tell their story and display drawings.

THE LIFE BOX

Objectives: Students will:

1. recognize water as an essential element of life, and

2. through exploration and discovery, learn the four essential elements necessary for life - sunlight, soil, air, and water.

Background

There are four things necessary for life to exist. The Life Box contains all four:

1. Rock. Rock is the origin of all soil. The breakdown of rock by physical and chemical processes is called weathering.

   Physical weathering, or disintegration, is caused by temperature changes (heating and cooling, freezing and thawing) and mechanical action (glacial ice movement, stream flow, wind, and waves).

   Chemical weathering, or decomposition, is caused by the oxidizing of iron in rock, and the combining of gases in the air with moisture. Both actions form acids that break down certain rocks.

   The formation of soil through weathering is a slow process. Evidence of the weathering process on solid rock can best be seen on those found in the channels of streams. The rocks are often worn smooth through years of water and ice flowing over them.

2. Air. Air is a mixture of numerous gases such as nitrogen, oxygen, hydrogen, carbon dioxide, argon, neon, helium, and others that make up the earth's atmosphere. Without an adequate supply of air, people would suffocate.

3. Sunlight. Sunlight is that which makes light possible. Radiant energy from the sun illuminates the earth and its moon. Plant photosynthesis is dependent on sunlight.

4. Water. Water is the combination of two colorless and odorless gases - hydrogen and oxygen. Man has more control over water than any of the other items in the Life Box. Man has used technology to better control the distribution of water. Plants and animals have also adapted to waterless and water-rich regions of the earth. Some animals can survive in the desert, while other animals are more suited to life in the rain forests.

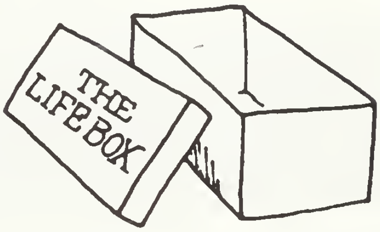
Materials:

Several small boxes with covers (shoe box size or smaller),
One small rock (per box), and
One small (leakproof) bottle of water with stopper (per box).

Procedure:

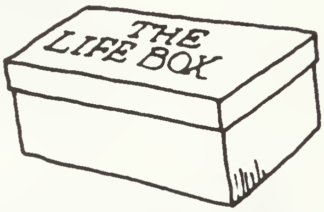
1. Collect the materials necessary to assemble several Life Boxes.

Label the box "The Life Box."



Place one rock inside each box.

Place one bottle of water inside each box.



Place the cover on the box before you start the activity.

2. Circulate the Life Boxes to your students. Ask each student to open the box and write down on a sheet of paper what is inside the box. After each student has examined the contents, he or she should place the cover back on the box and give it to the next student.

3. Ask your students to tell you what they found in the box. There is a good chance that they will answer a rock and a vial of water. Their interest will grow when you tell them that there are two more things in the box. Circulate the boxes again and repeat the question: "What is in the box?" If, after a short brainstorming session, your students still haven't identified air and sunlight, give them the answer. Tell your students that the box contains the four things necessary for life.

Actually, three things are in the box - water, rock, and air. The fourth, light, went in when the box was opened.

4. For life to exist, explain that all four elements must be present. (See extensions 1 and 2.)

Extensions:

1. Discuss the concept of habitat as it relates to the needs of humans and animals for food, water, shelter, and adequate space. Explain that food, water, shelter, and adequate space, when available in the proper quantities and qualities, are what are needed to have a healthy and prosperous living place or habitat. Point out that if one of the four is out of balance or is being affected by a problem (i.e. poor quality or inadequate quantities of water), the health and well-being of a living place is stressed. Have your students brainstorm some situations that could upset the balance of a system (i.e. drought, crowding, lack of food, etc.). Ask your students the following questions: "How has man adapted to the situations that upset the balance or harmony of a system? How have aquatic plants and animals adapted to the changes that upset the balance of a system (i.e. overcrowding, poorer water quality)?" Each situation lends itself to a research report or short essay.

2. Plant one bean seed in potting soil, water daily, and place the pot in sunlight.

   Plant one bean seed in potting soil, add water, and place the pot in a dark area.

   Plant one bean seed in potting soil, place the pot in a sunny spot; however, dry the potting soil in an oven or pan to remove moisture, and do not water the seed.

   Have your students monitor and record the results of this experiment. Discuss the importance of water (precipitation) to Montana farmers.

Evaluation: What are the four essential elements of life? (water, sunlight, soil, and air)

What four things are needed to have a healthy and prosperous living place? (food, water, shelter, and adequate space)

A DROP IN THE BUCKET

Objectives Students will:

1. better understand the world's water supply and how it relates to Montana's supply of water,

2. understand the hydrologic cycle,

3. understand the factors that influence a region's supply of water, and

4. better understand the importance of water management and water development in states like Montana that periodically experience drought conditions.

Background

Water covers approximately three-fourths of the earth's surface and is the most common substance on earth. The earth has so much water, in fact, that it has been called the water planet. Yet, as common as it is, water is also the most precious substance on earth. A contradiction? Not at all, for water is vital to life as we know it.

There are three primary kinds of water found on the earth. They are:

1. Atmospheric water - Examples of atmospheric water include water vapor, rain, snow, and hail.

2. Surface water - Some examples include oceans, lakes, wetlands, rivers, streams, and icecaps.

3. Ground water - Ground water is the water found below the earth's surface in the pores and cracks of subsurface rock formations.

World's Estimated Water Distribution

The oceans and seas contain 97.2 percent of the world's water. The water in the oceans and seas contains such high concentrations of salt that it is not drinkable.

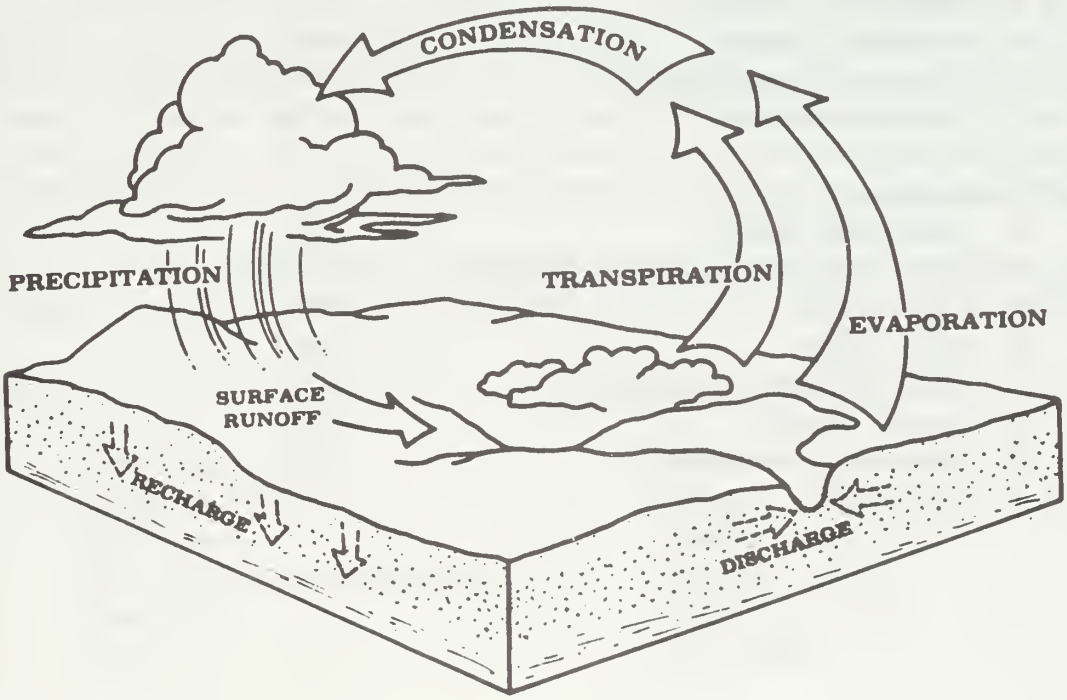
The second largest source of water is found in the world's icecaps and glaciers. This is high quality fresh water; however, it is not readily available to most water users. A little over 2 percent of the earth's water is locked in icecaps and glaciers.

The most accessible sources of water to meet man's drinking water needs are rivers, streams, lakes, and ground water found in rock formations below the earth's surface. The people of the world must rely on these sources of water which amount to less than two-thirds of 1 percent of the world's total water supply.

Source	Percent of Total Water
Oceans/Seas	97.21
Icecaps/Glaciers	2.15
Ground Water	0.626
Lakes	
a. freshwater lakes (.009)	
b. inland seas/salt lakes (.008)	0.017
Soil Moisture	0.005
Atmospheric Water	0.0019
Rivers/Streams	0.0001
Total	100.00

The Hydrologic Cycle

The earth's water is always in some state of motion. The endless circulation of water from the oceans to the atmosphere to the rivers and ground water and back to the oceans again is known as the hydrologic cycle. This complex process is driven by two natural forces: the sun's (solar) energy which causes surface water to evaporate into the atmosphere, and gravity which causes the water to flow downward or toward low areas.



Regional Water Distribution

The distribution of the earth's water is quite uneven. Some regions receive a great deal of precipitation each year, while other regions remain very dry. Location, proximity to major land forms (i.e., mountain ranges), climate (movement of air masses and temperature), and other factors affect the amount of precipitation an area receives.

Geographic influences on climate can cause precipitation amounts to vary widely within relatively small distances. For example, the west slopes of the Sierra Nevada Mountain Range in California receive an estimated 80 inches of precipitation a year. To the east of the Sierra Nevada Mountain Range, the landscape turns into a desert. Variations in precipitation are common around the world. Variations can be of great magnitude such as those observed on either side of the Sierra Nevada Mountains or they can be more subtle in nature.

High and Low Yearly Precipitation Amounts
for Selected Countries of the World

Reporting Site/Country	Average Precipitation in Inches/Year
High Precipitation	
1. Cherrapunji, India	425.1 (35 feet)
2. Andagoya, Columbia	281.1
3. Pago Pago, Samoa	193.6
4. Ponape, Caroline Islands	191.9
5. Tabing, Indonesia	175.4
Low Precipitation	
1. Wadi Halfa, Sudan	0.05
2. Aswan, United Arab Republic (Egypt)	0.05
3. Cufra, Libya	0.05
4. Arica, Chile	0.05
5. South Pole Station, Antarctica	0.1
6. Andras, Algeria	0.6
7. Walvis Bay, South Africa	0.9
8. Cairo, Egypt	1.1

High and Low Yearly Precipitation Amounts for
Selected Sites Within the United States

Reporting Site/State	Average Precipitation in Inches/Year
High Precipitation	
1. Yakutat, Alaska	132
2. Annette, Alaska	118.5
3. Miami, Florida	59.9
4. Jacksonville, Florida	53.6
5. Birmingham, Alabama	53.1
Low Precipitation	
1. Las Vegas, Nevada	3.8
2. Reno, Nevada	7.2
3. Phoenix, Arizona	7.3
4. El Paso, Texas	8.0
5. Albuquerque, New Mexico	8.4

Montana's Water

The amount of water found in Montana, at any given time, is a mere DROP IN THE BUCKET when compared to the worldwide supply of water. Montana shares only a very small percentage of the water found in the earth's rivers, lakes, and ground water. This, however, does not mean that Montana does not have enough water for, at times, the state has more that enough to sustain its needs. However, there have been times when Montana has had very little water. During these dry years, Montana's "drop of water" is not large enough to meet its needs.

Montana's water supply is not evenly distributed across the state. Precipitation ranges from an average of 12 inches per year in the northeast to 48 inches per year in the southwest.

Materials

- Gallon container
- Measuring cup
- Eye dropper
- Small metal Bucket (can or cup)
- Teaspoon
- Water
- Paper
- Scissor
- Globe or World Map
- Montana Map
- United States Map
- Encyclopedia

Procedure

1. Set up and lead your class through the following demonstration:

   a. Display and label as follows:

   b. Fill the gallon jug so that it is nearly full. Tell your students that the water represents the earth's total water supply.

   c. Pour 2 ounces of water from the gallon jug into the measuring cup. The water in the measuring cup represents all the earth's land water. Land water, for the purpose of this activity, is defined as the water found on and under the earth's land surface that is potentially available for man's use. This water may or may not be drinkable; for example, part of the land water is found in saline lakes. These lakes contain such high concentrations of salts that the water is not potable. The water remaining in the gallon jug represents the water stored in the oceans, seas, and polar icecaps (99.35%).

   d. Using the water dropper, remove several drops of water. The water dropper now contains all the water found in the world's freshwater lakes, rivers, and ground water.

   e. Now, release one drop from the water dropper into a small metal bucket. Make sure your students are very quiet, so that they can hear the sound of the drop hitting the bottom of the bucket. Refer to the "Drop in the Bucket" as Montana's share of the world's water. This one drop is precious and must be managed properly.

2. Another way to demonstrate the above concept is to:

   a. Prepare a piece of paper with 100 squares. The 100 squares represent all the earth's water.

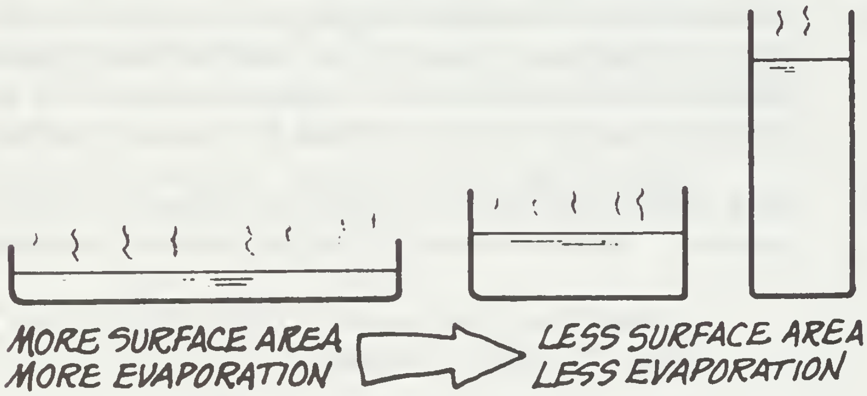
   b. Cut or color in one square and say this square represents all the earth's land water.

   c. From the earth's land water square, cut a small square from one corner. This square represents all the earth's freshwater rivers, streams, lakes, and ground water.

   d. Now, very carefully, cut a small corner off of the fresh-water square. Tell your students that this small piece of paper represents Montana's share of the earth's total water supply.

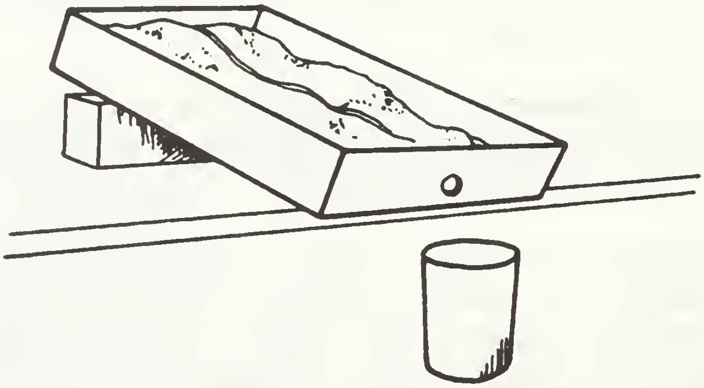
3. Lead your class through a discussion of the hydrologic cycle. Help your students visualize the movement of water by having each student draw and label his own hydrologic cycle on a piece of paper. Have your students think of experiments they could set up to show how water moves through the hydrologic cycle. Here are some suggested experiments:

   a. Place a pan(s) of water in a sunny area of your room. The water will evaporate. The larger the surface area of water exposed to the air and sunlight, the greater the evaporation.



   b. Leave a humidifier running in the room and watch the condensation form on the windows.

c. Fill a tray with soil (sand will allow for a faster response). At one end of the tray, drill an outlet hole. Place a container below the outlet. Elevate one end of the tray slightly. Now, sprinkle water on the elevated end allowing the water to soak into the soil. Some of the water will run off forming a channel; the rest will move through the soil the length of the tray and eventually flow out of the opening into the container. This demonstration will show runoff, ground water recharge, ground water movement and storage, and discharge to a surface water body.



Tell your students that there is a great deal of water moving around the earth in the air, through the ground, in the rivers, etc.; however, the percentage of water stored in the major sources (i.e. oceans, seas, etc.) remains relatively constant. You can also tell your students that the earth has the same amount of water today as it did a thousand years ago. People use water; however, people do not use it up. People merely use it and pass it on. This should not be interpreted to mean that people haven't changed the quality of some of the earth's water. Over many years of using water, some of the water has been contaminated. It can be concluded that the earth has been contaminated and is not suitable for use. This reduces the amount of water available for human and animal water use.

4. Have each student select a country and prepare a written report on its water resources. The report should include the following information:

   1. A description of the country. This should include a world map showing where the country is located.

   2. A description of the country's major land features: (i.e., mountain ranges, rivers, lakes, reservoirs, and deserts). Also, list surface vegetation types (i.e., forests, prairie grass, desert plants, etc.) Once again, use a map. Make sure the names of the land forms are labeled.

3. A brief description of the country's climate. What types of weather are common? If available, include precipitation changes that affect different regions of the country. Ask your students to try to relate the precipitation changes to the country's different vegetation types (i.e., low rainfall - desert conditions; high rainfall - swamps).

4. A description of the country's major sources of income (i.e., agriculture - wheat, corn, etc.; oil and manufacturing.) Ask your students to try to relate the country's precipitation to the country's major sources of income.

5. A discussion of the ways that man has adjusted to the country's water conditions (i.e., dry conditions - irrigation; flooding - dikes and dams). Did man's intervention succeed or fail?

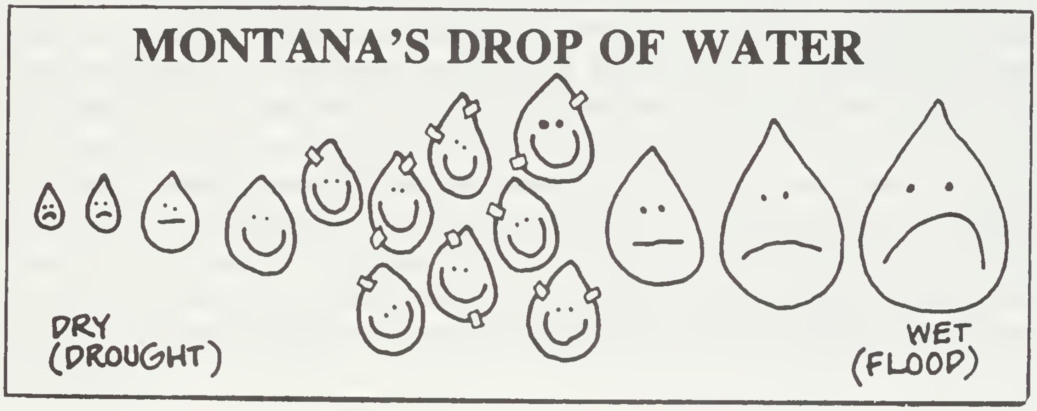
Have each student report his findings to his classmates. The goal of this section is to create a greater awareness of the differences in water availability around the world and to show that both ancient and modern societies have attempted, and are attempting, to improve their quality of life through water management and development.

Extension

1. Montana Water Drop (Poster)

This extension is for use in elementary grades.

A. Draw two raindrops on opposite ends of a large piece of paper. One drop should be small, the other large. Draw an unhappy face on the small drop and another unhappy face on the large drop. In the middle of the poster, as shown below, draw a few happy-faced drops.



B. Tell your students that the small drop represents times in Montana when there is little water (drought). The large drop represents the very wet times (floods).

C. There is a range of drop sizes between the dry and wet drops. Have your students draw their own mid-sized drop on a sheet of paper and cut it out. This mid-sized drop contains enough water for farmers' crops and livestock, for towns and rural water systems, and for industry.

D. Assignment: Ask each student to draw a picture of something that relates to water on his drop. Remember, this is a happy rain drop. When the drawings are finished, have each student paste his rain drop on the poster near the mid-sized happy face drop. Ask each student to explain his drawing.

LIFELINES

Objectives: Students will:

1. explore some of the ways that Montana's rivers, streams, and lakes (waterways) influenced the state's settlement and development patterns,

2. understand why many of Montana's historical sites and major cities were located on the banks of the waterways, and

3. learn about the changes that have occurred on the waterways.

Background

Montana's rivers, streams, and lakes were the focal points of early activity during the settlement years. Waterways have historically provided a readily available path for exploration and transportation. Land areas adjacent to the waterways were also the first areas in the state to be settled and developed. Evidence of the waterways' importance is reflected in the location of the state's major historical sites and major cities.

It is no coincidence that so much activity took place near the waterways. The availability of natural resources enticed the first migrants to the region to settle the land along the waterways before settling upland areas. The waterways were inhabited by wildlife which served as a food source for the pioneers. The fertile soils of the river bottoms were well-suited for growing crops, and the trees along the waterways were used for shelter, fuel, and building materials.

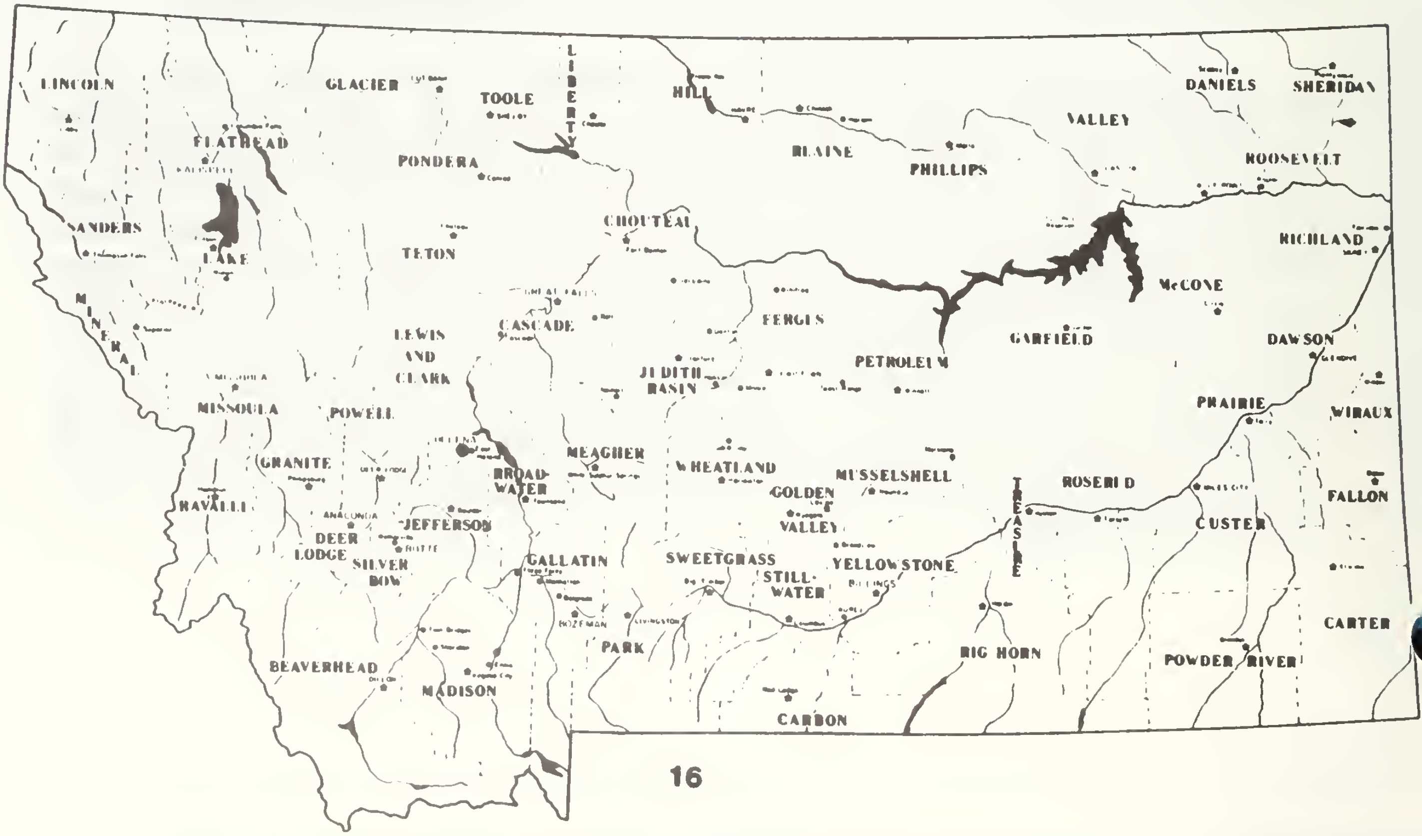
The proximity to water presented both advantages and disadvantages. The primary advantage was the convenience of being close to a source of water. The closer an individual was located to water, the less time and energy he or she invested in hauling it. However, the pioneers who lived near water learned a hard lesson during the wet years. Floods inundated many river towns and farms. A legitimate question one might ask is, "Why did many people build so close to the water?" It is reasonable to speculate that the settlers built their homes during years of moderate precipitation when the river water levels were relatively low. In most cases, their knowledge of the flooding history of the area where they built was very limited. Once the settlers built their homes and businesses in the flood-prone areas, these people were reluctant to abandon their buildings and relocate to higher ground. Instead, most of Montana's towns that experienced floods in their developing years continue to have flooding problems today. For the most part, the response has been to try to manage floods, rather than to limit development in areas prone to flooding.

The waterways provided many opportunities for people to harness and use water. Farmers developed systems to irrigate their crops, power plants were constructed to generate electricity, and grist mills were built to grind grain. Small, crudely constructed rock and earth dams were often constructed near the mills to assure a steady supply of water during low flow conditions.

Water development projects have changed Montana's waterways forever. Dams have inundated thousands of acres of river bottom land. In Montana, only a portion of the original 480 miles of the free-flowing Missouri River remains because of the presence of Canyon Ferry Lake and Fort Peck Lake, reservoirs created by Hauser Dam and Fort Peck Dam. These large multi-purpose dams were constructed to meet the water development needs of many groups of people. For example, the dams provide flood control protection for river towns; hydroelectrical power to homes and businesses; water for irrigation development; water for municipal, rural, and industrial water users; water for recreation; and water for fish and wildlife habitat.

There are other types of waterway developments that also cause change. Dikes have been constructed along waterways to reduce the amount of land flooded by rivers. Channels and drainage ditches have been constructed to move water off the land more quickly than natural drainage allowed. In addition, massive canals have been constructed to move water from rivers with an abundance of water, such as the Yellowstone River, to areas of the state with poor quality and/or inadequate quantities of water.

It is important to realize that every generation of Montanans has attempted, in one way or another, to make use of the waterways. Some groups would call the development that has taken place destructive, while others would call it progress. This activity will provide your students with a historical perspective of Montana's waterways and their importance to the state's early settlement and development.



Materials

Outline map of the state of Montana
Reference material on Montana's historic sites
Montana highway map

Procedure

1) Explain to your students that they will be studying the importance of water to the settlement and development of Montana. Have your students brainstorm a list of the state's major historical sites (i.e, forts, Indian villages). List the names on the blackboard or on an overhead transparency.

2) Have each student select one historic site (excluding battlefield sites) and write a short essay on why the student feels the historic site is located where it is. What was the main purpose of the site? Were there any unique or special features that might have caused the people to settle at this particular site or might have caused someone to travel a particular route (i.e., Lewis and Clark)?

3) Draw a large map of Montana on the blackboard or on an overhead transparency. Provide each student with an 8 1/2 x 11 inch sheet of paper with an outline of Montana drawn on it. Have your students develop a list of Montana's major rivers, streams and natural lakes. Each student should draw in the locations of these waterways and label them on their maps.

4) Have each student (one at a time) locate his or her historic site on the large map. Does a pattern take shape as to the location of the sites? There is a good chance most of the sites will be located near a waterway. If not, why? (i.e., railroads influenced the location of many Montana towns, such as Billings, Dillon, Havre, Great Falls, and Townsend. If surface water was not available for the railroad crews and locomotives wells were dug. Fortunately, ground water is widely available throughout the state.)

5) Have your students draw in the location of Indian villages, military forts, fur trading posts, and the routes of some of the early explorers (i.e., Lewis and Clark). Use symbols to locate each site (i.e., an arrowhead for an Indian village, a cannon for the military forts and camps, and a canoe paddle for the trading posts). Why was water important to each group? How did each group use water? Did any of the groups attempt to develop the waterways? In other words, did they cause any changes to the waterways? List some of the changes.

6) Next, have your students draw in the locations of Montana's major cities (Billings, Great Falls, Missoula, Helena, Bozeman, and Butte) and other towns of interest. What role do you think the rivers played in the location of the cities? (The rivers acted like dams backing up westward expansion and once bridges were built, they provided a safe passage for westward expansion.)

7) Draw in the Burlington Northern Railroad lines between Glendive and Missoula and between Wolf Point and Kalispell. How many of the cities are located near rivers?

8) Have your students list and explain the advantages and disadvantages of living near a waterway.

9) Most Montana towns and a large percentage of Montana's farmers and ranchers live on the prairie away from rivers, streams, and major lakes. Where do these groups of people get their water?

Evaluation

What effect, if any, did water have on the settlement of Montana?

List four reasons why people settled near the waterways.

Why are so many Montana towns located in areas that periodically flood? Why didn't the people locate on high ground at the time they settled?

YOU'RE SHOWING YOUR AGE

Objectives: Students will:

1. review some of the water-related factors which influence the location of native forests,

2. analyze a cross section of a tree to determine the tree's age, and

3. attempt to relate the spacing between the annual growth rings on the cross sections to wet and dry years.

Background

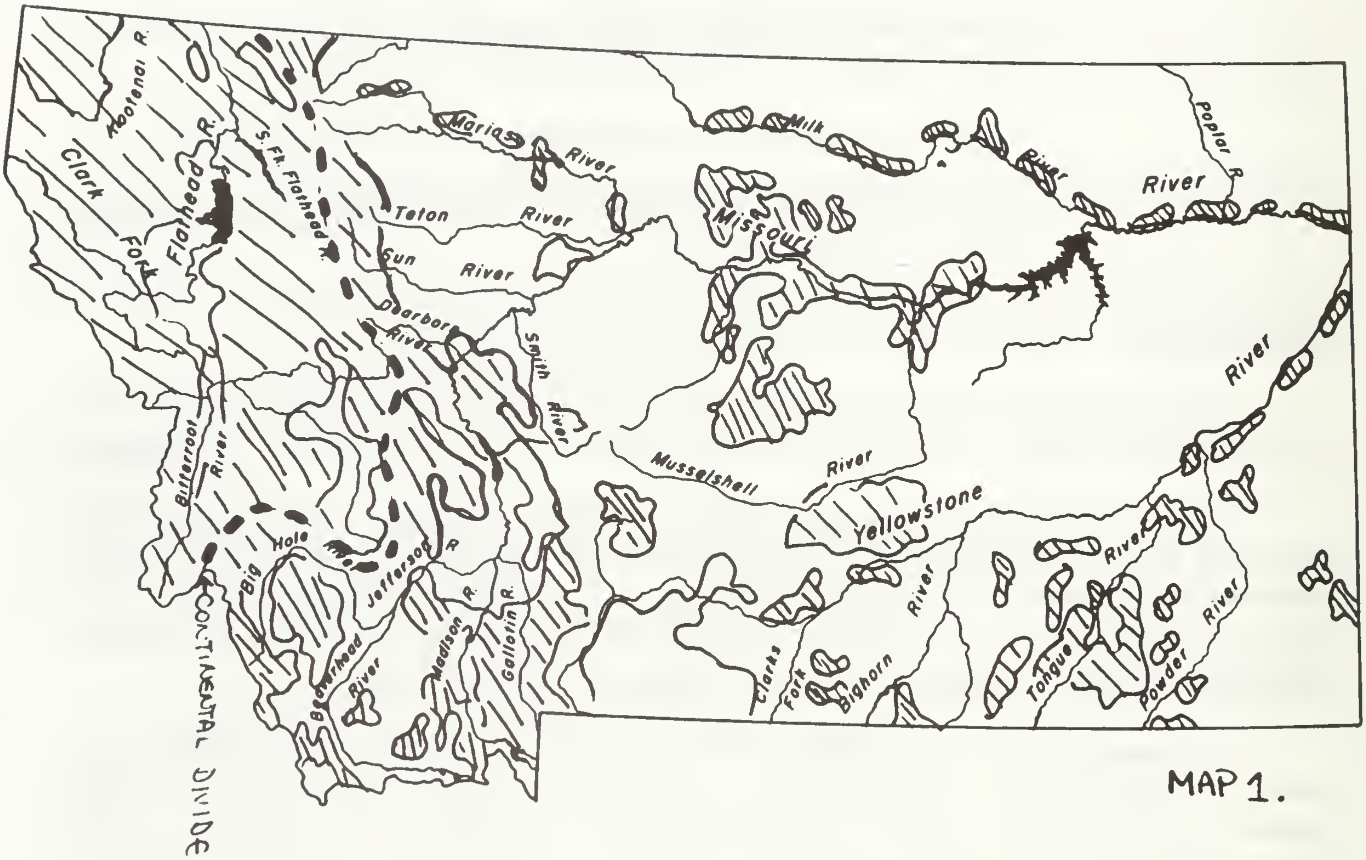
Forests cover one fourth of Montana's total area. This amounts to about 23 million acres of forested land, a figure which has remained relatively constant over the past 25-30 years.

Native forests have played a key role in the state's economy, and their use greatly influences the environmental quality of much of the state. At one time, many small sawmills provided early homesteaders with lumber for homes, barns, and fences. The forest resource also provided valuable fuel for steamboats and trains as well as heat for homes. Today, Montana still depends on its timber industry as an important source of income and jobs.

An appreciation for the presence and diversity of Montana's forests comes from understanding a variety of ecological factors. The vegetation and tree cover of an area is the product of the climate, the soil, the grazing intensity of animals, the prevalence of fires, topography, and water, or better stated, the lack of water. These factors, when blended together, will dictate the kinds of plants and animals that can inhabit an area. Ecologists call these distinctive types of terrestrial (land) ecosystems "biomes". Biomes are subdivided by geographic or climatic barriers. In Montana's case, the Rocky Mountains, with their wringer effect on westward-moving storm fronts, constitute a geographic barrier. The state's northern location results in extremely variable temperatures and a short, but productive, growing season (warm season).

Water is an important limiting factor for most trees. For example, there is a reason why willow trees do not grow on the tops of hills. The willow is a water-loving tree (phreatophyte), needing a wet environment to survive. Another example is what happens when a southern tree species is relocated to a northern climate. The tree will usually die. Foresters recognize that certain kinds of trees are far better suited to dry or wet regions than others. Trees like the Lodgepole Pine and the Douglas-fir are well-suited for most Montana conditions.

Map 1 shows the locations of major wooded areas and rivers. Woodland habitat is common along most rivers from the Clark Fork along the western border to the Yellowstone and Missouri in the east.



MAP 1.

In addition to native forests, Montana has many thousands of acres of trees in shelterbelts and farm and ranch woodlots. With human assistance, these trees beat the odds of the harsh prairie climate. The best success rate for planted trees is obtained when the trees are cultivated to remove water hungry weeds and grasses. Cultivation is especially important the first few years after planting. People often haul water in tank trucks to the young trees to keep them alive during dry spells.

Tree Growth Rings

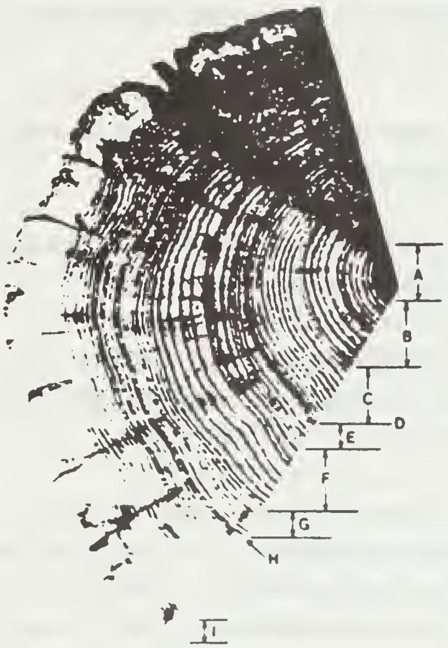
The life story of a tree is written in its annual growth rings. A tree's growth characteristics are influenced by environmental conditions such as the adequacy of minerals, water, and sunlight, and competition with other plants. The story begins at the center of the darker wood, or "heart wood", and continues through to the lighter sapwood.

The concentric tree rings found when examining tree stumps or the ends of logs consist of alternating layers of porous springwood and dense summerwood. Each year the tree adds a light-colored ring of springwood and a darker ring of summerwood. Combined, the two are

known as the annual ring. By counting either type of ring, the age of the tree can be determined. When determining the age of a tree, remember the tree adds both kinds of rings each year, so just count one type.

Notice that some rings are wide and some are narrower. The width of the space between each year's growth rings is, to a large extent, determined by the amount of moisture the tree receives. A very wide ring would indicate a wet year. Some insect infestations and certain tree diseases can also influence the space between growth rings.

Reading Growth Rings



Life stories of trees are written in their annual growth rings. The story begins at the center of the darker wood, or heartwood, through the lighter sapwood.

A. Decay caused by a heart rot fungus has consumed the first few years of growth.

B. Good even growth in the early life of the tree.

C. Growth is slowing because all the trees in the forest are getting larger; their moisture and nutrient requirements are also increasing. The trees are starting to compete with each other.

D. Three extremely close rings caused by either three years of drought or a three-year attack by insects such as defoliators (leaf feeders).

E. Five normal years of growth.

F. Tree reaches height for getting full sunlight or overshadowing tree topples.

G. Major trunk branch broken off or other injury.

H. Two dry years or insect attack.

I. Sapwood (wood containing living cells). In a live tree, this is encircled by a living cambium layer and outer bark layers.

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The last or newest growth ring is the ring just under the bark. The first ring, representing the very small or young tree, is the ring found in the center. By counting all the rings you can determine the age of the tree. If you know when the tree was cut, then subtract the age of the tree from that year. This will indicate when the tree began to grow.

<u>*Procedure*</u>

1. Review the background information with your students. Have your students consider the following questions.

* Where do you find most of Montana's native forests? (near rivers, streams, lakes, and wetlands) Why? (These areas catch and hold water.)

* What environmental factors influence the location of native forests? (climate, soil types, grazing intensity of animals, prevalence of fires, topography, and water) Why?

* Name a few ways climate has influenced the location of Montana's native forests. Name the kinds of trees that survive (or even thrive) in the harsh prairie climate. (precipitation, temperature, and length of growing season)

* What environmental factors in Minnesota and Montana have caused these two states to have a much larger percentage of native forests than North Dakota? (Montana has the mountains which wring moisture out of westward-moving storms. Minnesota is in the pathway of the northeast-tracking storm fronts. Both situations result in larger amounts of precipitation.)

* Why are you more likely to find trees and shrubs growing in and along ravines than out on flat ground? (These areas catch and hold water.)

2. Review the importance of trees to the pioneers. (Firewood, protection, building materials, and food, if the tree is a fruit bearing tree.)

3. Determining the Age of a Tree - Calculating the age of a tree is a fun hands-on activity. A cross section of a tree is sometimes called a "tree cookie" or "tree disc".

If a tree is being harvested in your community, have a slice about 1 1/2 inch thick removed from the butt end of the log or from the stump. After the slice has dried, sand one side of the disc. This will make the rings easier to see. NOTES: 1. Trees such as aspen, cottonwood, and basswood should be avoided because their growth rings are so faint they are almost impossible to see without using a special dye. 2. Try to obtain a wood disc from a tree growing on the prairie or in town. If the disc is obtained from a bottomland forest, along a river or creek bottom, its chances of suffering from drought are remote because of available moisture from the watercourse.

Explain to your students that the width of the growth ring or amount of wood added each year is dependent on the amount of moisture available to the tree. During years when moisture (snow melt and rain) is in excess of normal, the amount of growth would be greater than normal and would be represented by a wide growth ring. Conversely, the growth of the tree would be less than normal during a dry year, resulting in a narrow growth ring. Some rings may be wider or narrower on one side than the other, depending on the number of roots present and competition from other trees on each side.

Distribute the tree discs to your students or to groups of students. The students should measure and record the various ring widths using a pair of dividers and a ruler to find the average size ring. The students should list the dry, the wet, and the average years in separate columns. Are there more wet years than dry years? Are average moisture years more numerous than both wet and dry years?

The instructor should count the rings to determine the age of the tree. Make a list of historical events that have happened since the tree started its growth. Each student should select one of the historical events, research, and write a story about that event.

Mount the wood disc on a wall or bulletin board. Mount the various research papers around the disc. Have the students locate the growth rings representing the years in which the events of their stories took place. Put pins in these rings, then attach yarn or string to the pins and run the yarn to the associated stories. This will indicate the size of the tree (excluding the bark) when each event took place.

Possible events include:

* Lewis and Clark traversed Montana in 1805.
* Fort Union (American Fur Company) was established near the mouth of the Yellowstone River in 1828.
* Gold was discovered at Gold Creek by James and Granville Stuart in 1858;
* Steamboats reached Fort Benton in 1860.
* John Bozeman was slain by Indians in 1867.
* Northern Pacific Railroad reached Miles City from the East in 1881.
* Montana statehood was proclaimed in 1889.
* Glacier National Park was established in 1910.
* In 1949, construction began on Canyon Ferry Dam.
* In 1959, a severe earthquake in the upper Madison River valley resulted in 19 deaths and the formation of Quake Lake.
* The giant Bell Creek oil field was discovered in the Powder River valley near Broadus in 1967.
* Dates of major blizzards, floods, earthquakes, and other natural disasters.

Tree cookies from small diameter trees make excellent name tags. If available, the cookies can be given to each student to take home.

Extension

Compare and contrast the various climatic and topographic changes that occur from one region of the western states to another. Compare western trees to eastern trees. Compare northern trees to southern trees.

Next, have your students look for similar types of trees/vegetation patterns from one region of the world to another (i.e., arctic vegetation compared to vegetation near the equator).

"BACK TO THE FUTURE"

Objectives: Students will be able to:

1) understand the importance of streamflow and precipitation data collection,

2) understand how precipitation data and streamflow data is collected and used,

3) participate in a class precipitation monitoring network, and

4) graph, analyze, and interpret actual streamflow and precipitation data.

Background

The collection of data is an important component of most, if not all, scientific investigations. A lot of time, energy, and money has been invested into programs specifically designed to collect data. This activity focuses on the collection and use of precipitation data and streamflow data.

Precipitation data and streamflow data form the foundation for most water investigations. Because water managers use the data to help make decisions on water problems, the accuracy of the data is critical. The number of sampling points and the length of time the sampling points have been collecting data will determine the usefulness of the data. Many research projects fall short of expectations because the projects' scope and anticipated results are far too ambitious for the data that has been collected. For example, if you were interested in monitoring the changes in mean (average) annual precipitation in Montana, the quality of your analysis would depend on how many data collection sites there are across the state and the period of time that data has been collected at those sites. Cost usually dictates the number and type of sites in a monitoring network.

A. Precipitation Data Collection

Precipitation records for some Montana recording sites date back to the late 1800's. Modern precipitation data is collected by weather observers and by National Weather Service offices located across the country. The National Weather Service currently maintains a network of over 200 weather observers located around the state. These weather observers, as the name implies, are people that observe and record basic local weather characteristics such as precipitation (24-hour period) and temperature (high and low), and inclement weather (i.e., blizzards, tornadoes, and hailstorms).

The weather observer reports are forwarded to the National Weather Service at least once a day. Thereafter, the frequency of an observer's report is determined by the changes in a region's weather conditions. For example, weather conditions like severe thunderstorms and winter blizzards require constant monitoring and more frequent reporting. Meteorologists at the National Weather Service, with the aid of sophisticated weather monitoring equipment (i.e.,

radar, satellite images, and computer models), will develop reports and forecasts for the media to distribute to the public. The National Weather Service monitors the weather conditions hourly at its Great Falls office and reports the information to airports which generate flight data.

Table 1 contains precipitation data from a recording site near Glasgow, Montana for 1875-1988. This data will be used by your students to generate graphs.

B. Streamflow Data Collection

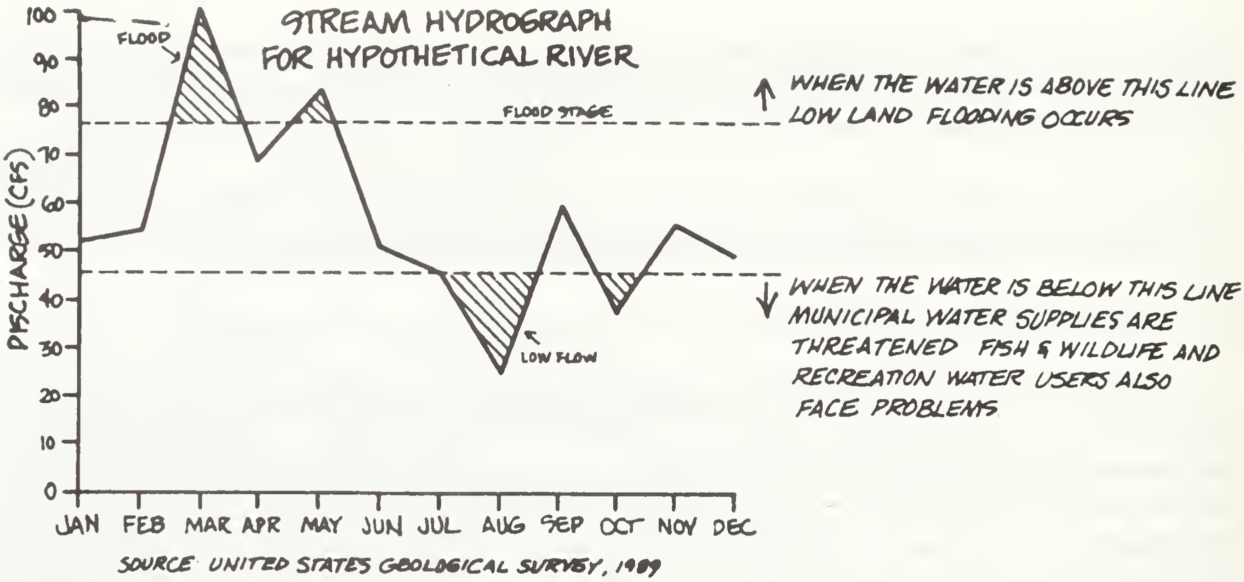
Streamflow data is collected by many Montana agencies including the Montana Geological Survey, U.S. Geological Survey, and the National Weather Service. Streamflow data is a measurement of the volume of water passing a given point over a given period of time. Streamflow data is collected at stream-gaging sites located on many of Montana's larger rivers and streams. The data is recorded at the gaging station as stream height and then is mathematically converted into cubic feet per second (cfs). There are 7.48 gallons of water in one cubic foot. For example, when the gaging station located at Corwin Springs on the Yellowstone River reads 11.5 feet, as it did on June 15, 1918, hydrologists know that 32,000 cfs of water is passing the gage each second.

The streamflow data is collected electronically or manually. The "electronic" sites typically record streamflow data around the clock, 365 days a year. "Manual" sites are monitored daily or after major precipitation events. The data can be used to develop stream hydrographs. A stream hydrograph is simply a graphical representation of its discharge or flow of water past a point over time.

Dams, water diversions, and land use changes in the river's watershed can influence streamflow. Dams tend to regulate the flow, while diversions reduce the flow. Collecting streamflow data helps to monitor these and other changes.

Historic streamflow records show that most Montana rivers fluctuate from periods of near zero flow to raging floods. The knowledge of a river's extreme highs and lows is as important as knowing about more normal conditions. Hydrologists use the data to create simulation models that can help predict streamflow under various precipitation conditions. The stream hydrograph on the next page shows when the river was flooding and when the river had low flow conditions.

Table 2 contains 100 years of streamflow data from a stream gage located on the Missouri River at Fort Benton. The Missouri River is regulated by Clark Canyon Reservoir, Canyon Ferry Lake, and 18 smaller irrigation reservoirs and powerplants. Table 3 contains 87 years of streamflow data from a gage located on the Gallatin River near Gallatin Gateway. The Gallatin River is not regulated by a dam or any other man-made structure. The hydrographs for the Missouri River will show moderate fluctuations in streamflow as compared to the Gallatin River which will exhibit large fluctuations.



Materials

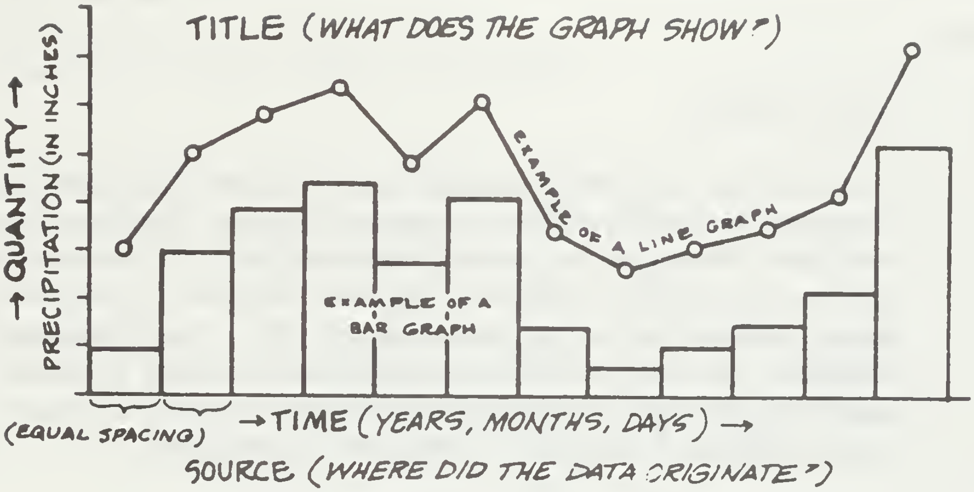
Hundreds of small pieces of paper (1" X 1" or smaller)
scissors
ruler
paper and pencils
graph paper (optional)

Procedure

A. Review and discuss the importance of collecting precipitation and streamflow data. Have your students think of some of the ways that the data is used (i.e., flood forecasting).

B. Discuss the role that weather observers play in recording and reporting precipitation and temperature data. Prepare your class to become weather observers. Each student should have a pencil and paper. Take your students outside and record the temperature and the precipitation for a 24-hour period. Here are some optional weather observations for your class to record: wind (yes or no), wind direction, and cloud cover (i.e., partly cloudy, foggy, or clear). Repeat the outdoor exercise four days in a row starting on Tuesday and ending on Friday. Save the results until the class has completed the graphing exercise. At that time, ask your students to try to remember the items that they recorded during the outdoor weather observations. This exercise should reinforce the importance of keeping good records.

C. Review the basic components of a graph.



D. Your students will now create four different line graphs.

Graph 1. Total annual precipitation for a 10-year period using data in Table 1.

Graph 2. Monthly precipitation for one year using data in Table 1.

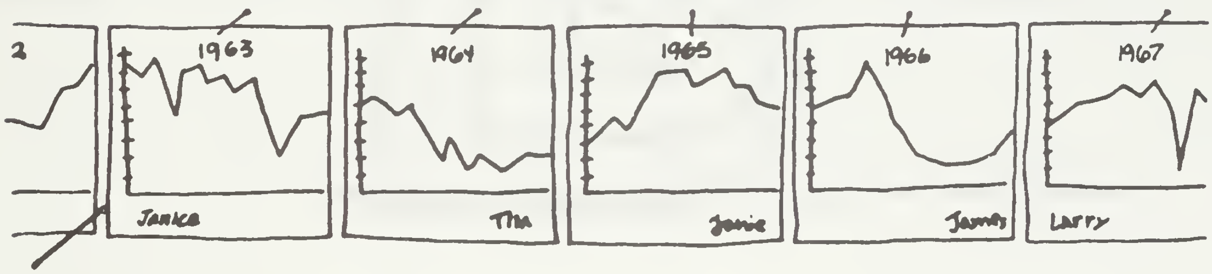
Note: Read the instructions in F before your students develop Graph 2 and Graph 3.

Graph 3. Average monthly streamflow in cfs of the Missouri River at Fort Benton or the Gallatin River using data in Tables 2 and 3.

Graph 4. Average annual streamflow in cfs of the Missouri River or the Gallatin River for a 10-year period using data in Tables 2 and 3.

E. Have your students complete the "Back to the Future" worksheet.

F. Visual presentation of data for Graph 2 and Graph 3.



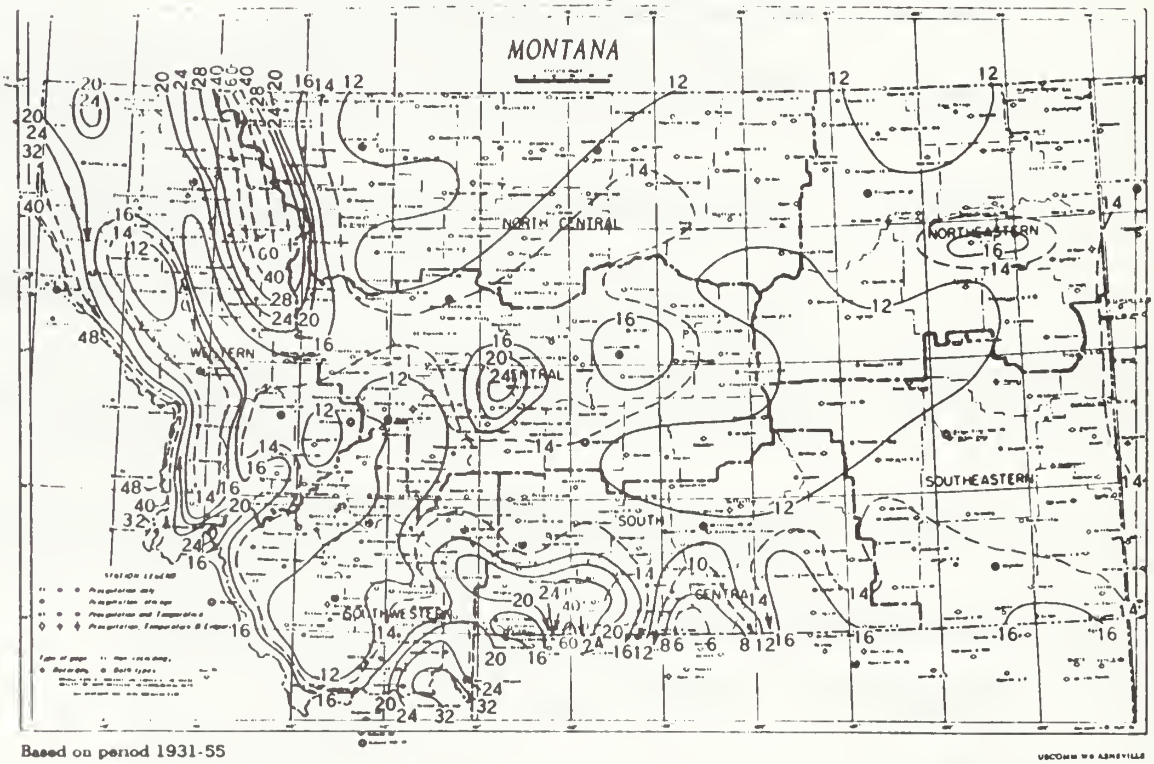
Once the graphs are completed, arrange the maps side by side (i.e., 1960, January - December; 1961, January - December; and etc.) on a

Extension

A. MAP PROJECT

Climatologists and hydrologists often use graphs and maps in the place of tables of numbers to explain and show the results of a study. Graphs and maps make the data easier to visualize and enhance understanding. For example, the following map was developed to illustrate the regional variations in precipitation instead of asking people to review precipitation data for the -plus monitoring sites across Montana. The lines on the map showing areas of equal or similar rainfall are called isohyetal lines. Your class will attempt to develop a similar type of map to show rainfall intensities for a simulated class rainstorm.

Mean Annual Precipitation, Inches

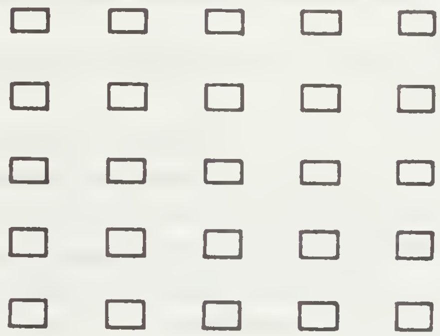


Based on period 1931-55

Annual Mean (Average) Precipitation in Inches for Montana

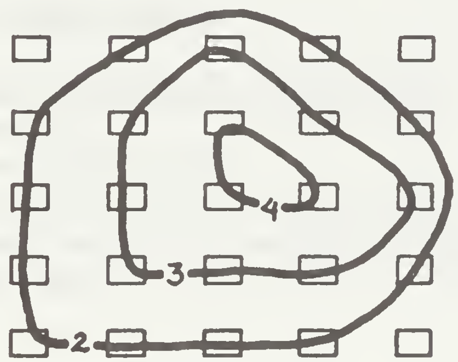
B. Discuss the importance of a well-developed monitoring network. Prepare by cutting or tearing hundreds of small pieces of paper and placing them in a bag or other container.

C. Arrange your students' desks in a grid pattern.



D. Have each student sit at a desk. Each student represents one point in the monitoring network. Stand near the center of the desks and throw the paper into the air; let the pieces settle to the floor, on the students, and on the desks. Have each student gather as many pieces of paper as he or she can without leaving his or her desk. Every ten pieces of paper equals one inch of rain.

E. Now on the blackboard, draw a scale drawing of your "monitoring network." Have each student count the number of pieces of paper he or she picked up and report the number to the class. Write each student's number in the corresponding square on the blackboard model. Complete the drawing by connecting the points of similar precipitation. What changes could have been made to the monitoring network to get better results? Would the results have been that much better if there had been more collection points?



F. Repeat Step C two or three times, throwing the paper into the air from different places in the room. This will allow the class to generate several different maps.

G. Relate the above maps to the maps developed by climatologists at the National Weather Service.

Credit: The United States Geological Survey provided the streamflow data used to develop Table 2 and Table 3. The National Weather Service provided the precipitation data located in Table 1.

"Back to the Future" Worksheet

*Student's Name:*______________________ *Date:*____________________________

Answer these questions about the graphs.

Graph 1. Average annual precipitation for a 10-year period.

What is the largest number? _______
What is the smallest number? _______
What is the range between the high and low? ____
What is the average for the 10-year period? ____
How many years were above average? _______
How many years were below average? _______

Graph 2. Monthly precipitation for one year.

Which month had the highest amount of precipitation? ______________
Which month had the lowest? _____________________________
Calculate the percentage of precipitation that arrived between April and September. ______
Why is it important that Montana receives more precipitation in the spring and summer than during the rest of the year? ____________________

Graph 3. Average monthly streamflow data for a one-year period.

During which month was the greatest amount of water flowing in the stream? _______
During which month was the least amount of water flowing in the stream? _______
What is the range between the high and low? ____

Graph 4. Average Annual Stream Flow.

Which year had the highest average annual streamflow? ____
Which year had the lowest? ____
What is the range between the high and low? ____
Did you notice any unusual patterns in the graphs which might indicate a change in the flow of the river? ________________________.

Table 1. MONTHLY AND TOTAL (ANNUAL) PRECIPITATION DATA (in inches) AT THE GLASGOW, MONTANA RECORDING STATION FROM 1875 - 1988.

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1875	1.13	1.32	2.06	4.22	3.40	5.02	1.54	2.89	1.85	2.37	1.33	0.39	27.52
1876	0.78	1.45	3.27	2.77	5.74	1.24	1.48	6.55	5.61	0.30	0.86	0.87	30.92
1877	1.64	0.19	0.77	1.32	4.15	4.60	2.52	0.35	0.11	0.94	0.40	0.69	17.68
1878	0.00	0.26	1.46	5.71	3.15	2.78	1.17	2.79	0.67	1.45	0.21	0.58	20.23
1879	0.15	0.82	0.58	2.60	3.67	4.97	4.27	2.69	0.07	1.35	0.16	1.28	22.61
1880	0.30	0.16	0.69	3.65	2.76	2.32	2.02	4.82	0.72	0.27	0.87	1.17	19.75
1881	0.69	0.78	0.45	1.02	2.27	4.11	1.28	2.98	1.26	0.51	0.35	0.06	15.76
1882	0.23	0.30	1.22	3.56	3.46	3.88	4.31	0.30	1.74	1.44	0.46	0.43	21.33
1883	0.25	0.66	0.38	1.57	1.15	3.84	1.32	0.98	0.04	3.88	0.26	1.33	15.66
1884	0.38	0.87	0.60	2.20	2.56	3.63	3.62	3.80	2.34	0.92	0.73	1.71	23.36
1885	0.31	0.36	0.18	3.21	0.92	2.39	2.41	1.62	0.14	0.54	0.66	0.34	13.08
1886	0.62	0.54	0.94	1.49	1.73	2.03	1.43	1.45	0.38	0.65	1.24	0.76	13.26
1887	0.95	0.52	0.78	1.52	2.19	0.85	4.49	1.62	1.35	1.15	0.11	0.80	16.33
1888	0.96	0.44	0.87	0.11	0.70	5.77	3.96	1.73	0.33	1.02	0.38	0.24	16.51
1889	0.50	1.48	0.55	0.26	3.35	1.03	2.01	0.53	0.48	0.00	0.15	0.69	11.03
1890	0.80	0.27	0.49	0.68	0.57	8.40	1.14	0.69	0.98	1.37	0.14	0.22	15.75
1891	0.05	0.57	1.24	2.40	2.92	4.19	4.20	1.43	0.87	0.99	1.20	0.44	20.50
1892	0.29	0.55	0.95	3.23	1.79	3.49	3.13	2.40	0.66	0.86	0.66	0.16	18.17
1893	0.73	0.20	1.52	0.69	1.26	4.33	1.48	0.67	0.18	0.95	0.24	1.49	13.74
1894	0.20	0.04	2.27	3.40	0.77	1.76	0.30	0.42	3.83	0.87	0.40	0.06	14.32
1895	0.89	0.35	0.24	2.53	3.80	4.01	2.08	0.40	0.67	0.08	1.60	0.27	16.92
1896	0.81	0.31	0.84	2.23	1.98	2.64	1.03	1.77	1.42	0.48	3.10	0.03	16.64
1897	1.11	1.32	0.91	1.40	1.10	3.44	1.53	2.25	0.30	0.42	0.25	0.30	14.33
1898	0.20	0.48	1.00	1.12	2.65	1.21	1.64	1.35	0.76	2.66	0.16	0.44	13.67
1899	0.09	0.18	0.88	1.31	4.30	5.57	0.45	0.97	0.06	0.55	0.47	0.64	15.47
1900	0.28	0.30	2.24	0.58	1.26	2.32	1.14	2.92	4.27	1.43	1.03	0.11	17.88
1901	0.03	0.16	0.96	0.36	0.04	5.17	3.24	1.01	1.47	1.89	0.30	0.96	15.59
1902	0.05	0.21	2.70	0.26	3.00	3.63	2.54	1.84	0.41	1.21	0.00	0.10	15.95
1903	0.82	0.09	0.12	0.61	3.20	1.44	2.18	5.59	2.36	0.27	0.23	1.05	17.96
1904	0.58	0.72	1.09	1.38	0.77	4.36	0.90	0.68	1.03	1.24	0.03	1.39	14.17
1905	0.31	0.54	1.16	0.07	1.87	5.61	3.24	1.71	0.94	0.30	1.36	0.08	17.19
1906	0.71	0.06	0.32	0.85	5.37	4.78	1.15	2.04	0.60	0.32	1.38	0.64	18.22
1907	1.01	0.57	1.09	0.67	1.98	3.63	4.32	0.61	1.19	0.80	0.36	0.32	16.55
1908	0.24	1.07	1.35	1.73	2.89	2.29	0.82	2.44	0.59	1.81	1.60	0.08	16.91
1909	0.21	0.36	0.27	0.84	4.43	2.19	2.41	4.77	0.83	0.78	0.41	1.05	18.55
1910	0.57	0.57	0.54	0.59	0.71	2.95	0.93	1.26	2.66	0.75	0.14	0.31	11.98
1911	1.50	0.42	0.31	1.18	1.18	2.73	1.13	2.72	2.26	0.71	0.78	0.30	15.22
1912	0.18	0.08	0.70	2.30	3.03	3.55	3.18	2.33	2.42	0.94	0.00	0.40	19.11
1913	0.37	0.03	0.49	0.55	1.99	2.06	2.72	0.77	2.29	1.13	0.16	0.28	12.84
1914	0.25	0.36	1.23	0.92	3.61	9.90	2.04	2.02	1.10	0.79	0.42	0.34	22.98
1915	0.08	0.03	0.35	1.04	4.43	5.70	4.02	3.44	1.68	1.52	0.57	0.39	23.25
1916	0.81	0.39	3.27	0.65	1.95	1.50	4.03	1.97	0.70	0.18	0.13	1.52	17.10
1917	0.65	0.44	0.60	1.87	0.26	2.15	1.50	1.37	1.75	0.21	0.04	0.59	11.43
1918	0.62	0.29	0.85	2.13	2.03	0.59	2.09	2.62	0.47	0.28	0.51	1.02	13.50
1919	0.09	0.63	1.17	1.71	4.06	0.63	0.76	1.46	0.34	0.98	0.92	0.23	12.98
1920	0.52	0.20	1.21	0.45	1.27	2.05	2.72	0.59	1.20	0.26	0.39	0.29	11.15
1921	0.12	0.15	1.00	2.40	2.72	0.92	2.18	0.18	1.67	1.58	0.84	0.29	14.05
1922	0.34	1.55	0.70	0.68	2.65	3.24	2.77	0.22	1.93	0.63	1.51	0.94	17.16
1923	0.29	0.46	0.28	2.01	1.01	1.99	4.77	0.63	2.83	1.03	0.29	0.22	15.81
1924	0.04	0.28	0.58	1.90	0.45	6.21	1.40	1.91	1.60	2.02	0.05	0.23	16.67
1925	0.32	0.05	0.46	0.86	1.14	6.82	0.42	1.69	0.85	0.55	0.13	0.35	13.64
1926	0.54	0.35	0.00	0.11	2.69	1.81	1.84	1.34	2.31	0.23	0.51	0.64	12.37
1927	0.24	0.19	0.90	1.37	7.04	2.72	2.26	3.12	0.47	0.53	0.80	1.20	20.84
1928	0.23	0.11	0.32	1.15	0.58	4.81	5.06	2.11	1.15	0.19	0.07	0.24	16.02
1929	0.69	0.32	1.61	1.87	2.37	1.09	1.06	0.75	1.69	1.82	0.25	0.81	14.33

Table 1. **Continue.**

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1930	0.23	1.36	0.00	1.37	2.19	2.19	1.90	1.71	2.70	1.94	0.98	0.19	16.76
1931	0.05	0.74	1.26	0.42	1.94	1.66	3.39	1.58	2.81	1.19	0.25	0.53	15.82
1932	0.35	0.20	0.73	2.08	3.78	2.57	1.38	0.61	0.33	2.05	0.16	0.17	14.41
1933	0.83	0.22	0.68	0.73	2.38	1.95	1.61	0.48	0.37	0.44	0.74	0.43	10.86
1934	0.08	0.03	0.62	0.32	0.09	3.39	0.98	0.50	0.54	0.86	0.20	0.13	7.74
1935	0.04	0.29	0.99	3.03	2.25	2.82	5.46	1.14	0.38	0.00	0.82	0.71	17.93
1936	0.36	0.59	0.88	0.37	0.12	0.47	0.10	0.62	1.66	0.14	0.45	0.21	5.97
1937	0.70	0.39	0.58	1.43	1.52	6.09	2.17	1.12	1.19	0.49	0.41	0.51	16.60
1938	0.40	0.76	0.58	0.54	2.45	3.17	2.36	0.84	1.11	0.24	0.81	0.16	13.42
1939	0.32	0.63	0.21	0.69	1.57	5.42	2.52	1.81	0.24	0.81	0.01	0.26	14.49
1940	0.02	0.28	0.79	2.93	1.04	2.13	3.35	0.32	1.38	1.38	0.47	0.10	14.19
1941	0.57	0.14	0.79	1.60	1.03	5.64	2.32	2.91	3.91	1.01	0.31	0.09	20.32
1942	0.04	0.30	1.18	2.58	3.04	2.21	4.17	1.17	2.08	0.71	0.08	0.48	18.04
1943	0.75	0.53	1.31	0.87	2.05	6.44	2.15	2.72	0.23	1.54	0.58	0.33	19.50
1944	0.22	0.36	0.43	1.05	2.45	4.85	1.01	5.05	1.34	0.08	2.56	0.00	19.40
1945	0.39	0.21	0.98	0.98	0.97	1.74	1.98	2.76	1.99	0.07	0.27	0.39	12.73
1946	0.07	0.38	1.25	1.04	1.93	2.99	2.10	1.12	2.23	2.04	0.17	0.53	15.85
1947	0.45	0.29	0.21	0.90	0.79	8.29	1.68	1.13	1.50	2.34	1.00	0.26	18.84
1948	0.30	0.85	0.39	3.05	0.78	3.42	2.35	1.18	0.02	1.50	0.70	0.36	14.90
1949	0.74	0.37	0.31	1.70	2.15	1.24	4.18	3.25	0.54	2.06	0.20	0.52	17.26
1950	1.00	0.55	2.84	1.71	2.89	1.53	1.12	1.11	1.70	0.59	0.24	0.61	15.89
1951	0.55	0.80	0.28	0.49	1.21	2.29	3.84	4.89	0.76	0.41	0.20	0.91	16.63
1952	1.24	1.04	0.49	0.00	0.31	3.24	1.64	0.61	0.40	0.07	0.13	0.14	9.31
1953	0.43	0.34	1.77	2.44	4.40	5.68	0.87	0.94	0.42	1.03	0.45	0.41	19.18
1954	0.52	0.12	0.90	0.56	2.01	3.64	3.95	2.68	2.69	0.41	0.09	0.06	17.63
1955	0.42	0.43	0.26	1.77	3.21	4.59	1.68	1.04	2.26	0.26	1.19	0.35	17.46
1956	0.97	0.18	1.21	0.11	3.83	2.36	2.78	2.93	0.55	0.25	1.43	0.26	16.86
1957	0.43	0.23	0.25	1.61	2.77	2.56	1.58	1.58	0.74	1.59	0.42	0.38	14.14
1958	0.43	1.09	0.31	0.76	1.02	3.57	1.74	0.71	0.41	0.49	1.72	0.34	12.59
1959	0.29	0.41	0.24	0.37	2.21	2.54	0.41	1.15	1.57	1.44	1.34	0.39	12.36
1960	0.35	0.16	0.67	0.41	2.89	3.40	0.68	3.81	0.29	0.10	0.40	0.89	14.05
1961	0.05	0.56	0.11	1.70	0.80	1.78	1.50	0.43	2.81	0.50	0.01	0.88	11.13
1962	0.54	0.31	0.71	0.55	4.80	2.92	2.40	1.04	0.79	0.31	0.30	0.24	14.91
1963	0.32	0.48	0.29	1.98	2.61	5.45	2.76	1.39	0.72	1.18	0.00	0.81	17.99
1964	0.40	0.22	0.52	2.90	0.90	5.71	2.18	0.76	0.66	0.10	0.43	0.65	15.43
1965	0.54	0.21	0.46	1.88	5.18	2.57	3.35	3.39	3.02	0.46	0.18	0.29	21.53
1966	0.29	0.41	1.85	1.23	0.91	3.60	4.27	2.25	0.86	0.59	0.29	0.18	16.73
1967	0.85	0.68	0.28	2.79	1.67	0.85	0.29	1.21	2.09	1.72	0.16	0.95	13.54
1968	0.30	0.12	0.95	1.30	2.51	6.52	0.18	4.56	1.20	0.05	0.56	0.78	19.03
1969	1.29	1.17	0.15	0.77	1.57	2.01	5.24	0.92	0.49	0.30	0.06	0.79	14.76
1970	0.46	0.34	0.55	4.05	2.32	3.78	1.63	0.13	1.47	0.69	1.33	0.16	16.91
1971	0.78	0.41	0.30	1.06	1.34	3.86	1.04	0.03	1.63	3.74	0.59	0.47	15.25
1972	0.68	0.42	1.32	1.81	3.16	1.81	1.60	1.70	0.29	1.60	0.11	0.67	15.17
1973	0.07	0.08	0.55	0.87	1.77	1.15	1.24	0.30	2.32	1.40	0.46	0.63	11.04
1974	0.11	0.29	0.40	2.23	2.68	0.50	1.10	1.52	0.23	0.74	0.36	0.50	10.66
1975	0.53	0.47	3.19	5.46	1.81	4.60	2.63	0.64	0.57	0.71	0.19	0.70	21.50
1976	0.52	0.27	0.52	2.84	1.08	2.66	0.46	0.32	1.59	0.21	0.15	0.55	11.17
1977	0.55	0.33	0.71	0.13	1.09	2.35	1.39	1.92	6.93	1.00	1.36	0.78	18.54
1978	0.14	0.41	0.30	2.00	4.65	1.79	2.58	1.21	1.80	0.45	1.13	0.49	16.95
1979	0.54	1.21	1.15	0.94	1.07	0.76	3.22	1.73	0.82	0.10	0.05	0.22	11.81
1980	0.70	0.28	0.32	0.43	1.08	1.67	3.16	5.03	1.11	2.31	0.09	0.21	16.39
1981	0.12	0.42	0.09	0.58	0.90	1.67	3.69	3.32	1.88	0.52	0.79	0.48	14.46
1982	0.75	0.40	1.08	0.76	3.71	2.04	2.17	1.52	0.45	4.30	0.41	0.48	18.07
1983	0.23	0.44	1.65	0.51	1.46	2.95	2.04	0.87	1.03	0.75	0.73	0.48	13.14
1984	0.38	0.31	1.65	3.65	0.28	3.58	0.81	0.87	0.94	0.99	0.73	0.58	14.77
1985	0.27	0.03	0.80	1.77	4.13	1.80	0.55	4.61	1.29	1.33	0.91	0.35	17.84
1986	0.36	0.25	0.25	3.60	3.11	3.95	4.24	1.61	4.41	0.35	2.09	0.02	24.24
1987	0.14	1.65	1.34	0.13	4.19	1.52	4.59	3.03	0.29	0.10	0.02	0.13	17.13
1988	0.68	0.40	0.92	0.12	1.16								3.28

Table 2. MISSOURI RIVER DISCHARGE DATA IN CUBIC FEET PER SECOND (cfs) AT FT. BENTON, MONTANA FROM 1891 -1990.

Year	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept
1891	2932	3425	3035	2531	2500	4590	9256	17300	24240	18270	7538	4015
1892	4803	4468	4155	3500	4000	4938	4629	11440	40020	24960	6279	5046
1893	5575	5522	4000	3500	3900	5593	7691	16770	29040	14240	5321	4740
1894	4700	5879	4500	3500	4000	5597	13540	23600	39730	17300	7013	5677
1895	6112	6252	4709	2455	3500	5386	9991	16950	17640	9876	3939	4016
1896	4487	4040	3571	2500	4000	5543	5397	10930	34510	14290	6157	8000
1897	7000	5000	6000	4000	4000	5917	11360	23150	17940	10020	3706	3307
1898	4222	4533	4016	4161	4461	4405	10490	22550	32610	14260	4730	4245
1899	4909	4457	4152	3661	3232	3500	10380	19750	36350	23210	8241	5483
1900	5739	6417	4301	4903	4429	7916	9157	22450	16670	4548	2700	3500
1901	4500	4250	4645	3449	3232	5157	6245	24770	15890	5875	2377	2798
1902	3530	3921	3301	3225	3143	3625	4295	16550	19620	10720	3365	2904
1903	3699	4250	3500	4000	3500	4371	7392	12420	24430	10970	4000	3240
1904	4576	4500	5355	4500	4483	5386	10260	19950	22790	10170	4272	3266
1905	3956	4800	4753	4000	3946	5149	4692	5853	11740	6523	3171	2467
1906	2919	3833	3581	3355	4107	4742	7217	11670	17690	6537	2718	3527
1907	3530	3667	3516	2919	4580	6331	9914	15990	33020	25580	8047	5979
1908	6129	5500	4661	4323	4138	5891	9835	13560	53620	18910	5885	5852
1909	8323	7667	5645	4939	5464	7161	8321	15400	36660	13050	5802	7185
1910	7161	6593	4403	4577	4639	11800	15540	20690	12900	3903	2772	4206
1911	5146	5439	4591	3161	4089	6527	7079	11080	26240	9190	4147	3843
1912	5229	5517	4468	3952	4603	5455	9479	19560	29100	10460	6373	6239
1913	6869	6767	4565	3290	3839	4548	14400	21470	36590	13120	6791	4372
1914	7718	7365	4546	4606	5239	7206	10030	20390	23770	6675	3329	3933
1915	6792	6050	4516	4359	6475	9085	10450	14420	21290	11160	7455	6355
1916	6995	6228	5139	3984	6672	11240	9876	17390	31490	23290	7156	6217
1917	6419	5895	4813	5239	5800	7704	10930	26200	39040	15690	4504	4647
1918	5003	6133	4387	5839	5468	7392	3950	13920	19330	5729	5172	4503
1919	5188	5324	5149	5004	5057	6234	7092	9035	5496	2433	1866	2074
1920	2441	2789	2773	3620	4560	6104	6721	19560	23500	9541	4212	4304
1921	4520	5643	4391	3999	4595	5393	9553	17210	24640	7461	3393	3044
1922	4005	4623	5037	4185	3972	6109	9449	20730	27550	5254	4227	4606
1923	3979	4622	4549	4480	4451	5712	10760	15340	19060	9141	5341	4153
1924	4441	5017	4692	4327	6090	5435	9119	17270	9805	4198	3510	3716
1925	3977	4272	4187	4259	4882	5421	10140	17760	19800	8773	4301	5474
1926	6781	7020	6108	4990	5749	6693	12460	15900	6765	5617	4595	4829
1927	5025	4954	4643	4647	4690	5934	6927	21460	45710	12470	6320	7010
1928	7606	7381	5694	5099	6086	9342	10260	27590	18000	11300	5297	5143
1929	5339	5397	4987	4923	5734	5606	6325	13440	15840	5908	4640	5026
1930	5043	4531	4748	4697	4151	4464	12270	9632	6225	3341	3211	3682
1931	3786	3750	3318	4015	4539	4972	6018	5393	5413	2491	2626	2907
1932	2095	2325	2446	2377	2593	4855	6700	11030	15480	5190	4156	3564
1933	4034	4049	3000	3500	3750	5462	6307	11290	13320	4511	3247	3119
1934	3241	4784	4792	5214	4422	4989	10070	8541	7115	2664	1576	1890
1935	2782	2921	2930	3063	2931	4237	4497	7195	10620	3314	3464	3757
1936	3842	3379	3164	3052	2372	3452	4598	11200	8909	3920	3560	3695
1937	3971	3738	3525	2669	2492	4237	4340	4481	4592	3506	2809	2840
1938	3559	3099	2984	2769	3044	2985	4126	11510	19320	12370	3156	3128
1939	3733	5004	4402	3323	3554	6252	7747	11340	9127	3879	3296	3253
1940	3531	3422	3244	3152	3033	4025	5117	8270	9565	3393	3179	2920
1941	3150	3294	3900	3559	3637	4214	4604	4144	7949	3776	3038	3901
1942	5829	5259	5345	4767	4411	5732	12310	14590	23530	7161	3417	3552
1943	4291	5190	4975	4594	5357	7194	14910	14130	31340	11390	5137	4509
1944	4372	5090	4902	4454	4570	5394	5321	7055	19790	11370	4684	4322
1945	4569	4794	4710	4471	4667	5397	4794	7751	16570	6958	3524	3908
1946	4506	4612	4411	4770	4770	5349	7857	9717	10990	5791	3698	4678
1947	5744	5755	5519	5059	4849	8076	11170	19320	21750	8363	4079	5128

Table 2. **Continue.**

Year	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept
1948	6076	5944	5781	5366	5479	6056	11400	21880	30690	11920	6279	5393
1949	5195	5330	4739	4506	4708	6429	10130	14100	13400	4711	3178	3563
1950	4744	5167	4301	3923	4779	6235	6057	9454	20640	10280	6304	4962
1951	5265	6335	5213	5141	4937	6819	9448	19540	19100	8638	4936	5651
1952	6591	6157	5034	4645	5374	6918	11760	21790	14740	7552	4593	4166
1953	4022	5571	5028	5524	5119	5398	5047	10370	30750	7779	4130	3586
1954	3576	4319	5133	4935	5420	5151	5514	6345	8994	5602	3468	3402
1955	3922	4973	4409	5116	4800	5049	5274	7374	8440	6852	5095	4917
1956	5612	5643	6266	6205	6321	6205	6951	12190	14150	5280	5147	4986
1957	5294	5313	5493	5131	6204	6653	6036	7935	14350	6561	5155	5241
1958	5074	5250	5647	5953	6055	5598	6811	9952	11040	8067	5390	5220
1959	5417	5255	4946	4909	4535	5305	4837	11120	16770	7294	3937	3133
1960	5778	9909	11640	4806	4502	5091	8904	12590	9936	4714	4808	4923
1961	5314	5062	4886	5133	5507	3931	3574	4539	5374	4541	5015	4190
1962	3960	5125	5467	5439	5379	6093	5530	8717	14030	5411	5397	5668
1963	5389	5463	4325	5193	7653	5306	4927	8835	18050	7520	4738	4868
1964	5010	5315	5225	5723	5662	5401	5257	15080	31370	12400	6399	6307
1965	6324	6741	7324	7900	8783	8332	11720	18070	23100	15240	6206	8428
1966	12610	10850	7978	6610	6161	7997	8098	9010	6736	5187	4737	4042
1967	3955	4012	6161	7329	7712	7460	6433	11600	27510	13240	6790	5524
1968	5450	5734	5983	7508	7717	10750	9397	11500	16230	9265	6725	6289
1969	7854	7570	6755	7734	8348	10350	13750	15290	14300	15160	6951	5559
1970	5388	6025	6722	7104	7357	6790	8812	19480	21400	11400	7260	6431
1971	6314	7312	7013	6199	8752	8024	11040	20520	14830	11550	6597	6505
1972	7199	6659	6504	7309	9066	8500	9727	14070	16540	8900	7365	7364
1973	7715	7444	6991	6908	6806	5278	4850	6502	6876	5105	4267	3678
1974	4350	6037	6404	7127	7126	7249	8696	11420	19560	9813	7255	6557
1975	5294	5055	5198	7076	7130	7933	9580	22080	30270	23170	9225	8027
1976	8865	10190	9640	8067	7919	8797	13790	25430	18460	10500	7962	7585
1977	6983	7149	7087	7104	6472	5441	6506	6698	4055	3675	4461	3962
1978	5015	5058	6541	7052	9025	11010	9712	16140	15050	13110	7617	7826
1979	6421	7135	7065	7590	7529	9379	9911	13080	10310	5797	5457	4940
1980	4502	4441	5287	6193	5703	5900	7167	9850	22860	10320	5829	4440
1981	6005	6866	7432	7140	7498	7782	6521	19500	28520	9393	6309	4626
1982	4536	5395	5791	7232	8289	7965	9045	12910	24570	15840	7435	6341
1983	7504	7169	6065	7131	6939	7499	7542	11570	11300	14010	7418	6283
1984	7049	8977	6621	7683	7525	7798	8965	12750	13900	12530	7993	10240
1985	8458	7319	6981	7065	6954	6419	7153	8690	5921	3975	4518	4573
1986	7069	7509	7068	6781	7415	7799	8474	11790	11620	6834	5933	5702
1987	5214	5563	6309	5399	5091	4801	5595	5445	4159	4576	4346	4326
1988	3975	4041	4450	4905	4670	4405	4657	5975	4660	3969	3872	3940
1989	3586	3674	3729	4412	5161	7194	7153	10590	7486	4569	4532	4474
1990	4618	5251	11010	*	10080	5690	*	*	*	*	*	*

* Indicates a no-value month

Table 3. GALLATIN RIVER DISCHARGE DATA IN CUBIC FEET PER SECOND (cfs) NEAR GALLATIN GATEWAY, MONTANA FROM 1889 - 1990.

Year	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept
1889	*	*	*	*	*	*	*	*	*	*	425.0	450.4
1890	402.0	400.0	400.0	320.0	390.0	320.0	460.0	2092	2641	1388	702.3	507.3
1891	590.0	505.5	405.8	470.0	490.0	450.0	500.0	1897	2183	1534	762.3	583.3
1892	530.5	500.5	434.5	430.0	499.0	400.0	450.0	1438	4432	2544	957.3	734.0
1893	742.9	583.7	545.5	468.4	430.0	375.0	462.7	1414	3900	1300	622.0	587.3
1894	570.5	453.0	401.0	329.7	339.6	310.3	564.7	2926	4024	1390	750.0	610.0
1930	*	*	*	*	*	*	*	*	2395	954.4	631.4	445.8
1931	514.5	350.0	300.0	200.0	319.0	329.7	503.2	1460	1769	475.3	295.7	233.2
1932	233.2	307.3	290.3	272.2	276.6	255.4	352.0	1907	3810	1163	497.2	410.7
1933	308.0	324.4	260.3	283.7	264.5	257.9	381.4	899.5	3053	931.1	470.5	407.8
1934	315.0	300.0	290.0	296.0	234.4	295.2	574.0	1022	643.4	344.8	269.5	258.4
1935	265.9	248.7	214.4	217.6	220.4	205.5	314.5	894.3	2655	964.7	426.7	340.5
1936	301.3	270.0	240.7	233.6	225.4	224.7	585.0	2065	1517	518.7	398.8	319.5
1937	293.5	246.9	228.6	233.0	237.5	218.4	243.2	1502	1910	734.9	375.5	304.3
1938	291.0	267.1	239.7	233.5	226.3	227.1	372.5	1373	3153	1233	535.2	388.1
1939	422.4	332.4	277.7	273.4	269.7	315.7	567.5	2036	1512	824.5	433.5	360.3
1940	334.5	274.7	233.9	227.6	220.6	235.6	382.3	1968	2261	731.9	423.5	370.6
1941	353.0	270.4	253.5	248.0	241.1	248.7	314.4	1339	1534	601.9	426.3	542.9
1942	529.3	396.7	316.5	272.9	270.0	253.7	673.5	1401	2975	1490	537.0	405.3
1943	350.4	340.8	231.7	264.2	246.2	290.2	750.1	1727	4010	2023	670.3	458.6
1944	420.7	372.7	310.8	290.5	286.7	274.1	354.2	1499	2700	1240	547.6	473.5
1945	398.5	336.5	273.9	239.7	275.7	247.7	299.4	1091	2610	1567	605.3	477.8
1946	445.7	365.4	272.2	283.1	295.7	299.3	799.0	1736	2669	1132	501.3	441.9
1947	405.6	370.1	230.7	249.4	236.0	262.9	415.8	2519	3253	1839	693.3	539.0
1948	520.5	405.5	367.0	349.4	333.5	238.9	445.6	2488	3769	1269	719.7	506.9
1949	470.1	337.2	317.7	300.7	232.3	280.7	604.7	2196	2024	794.2	457.6	413.5
1950	395.1	353.0	277.5	236.5	251.3	276.5	417.3	979.4	3024	1831	734.3	523.8
1951	460.5	413.0	323.5	248.5	278.0	231.5	438.7	1985	2021	1149	637.0	452.2
1952	451.4	379.0	293.0	283.0	270.3	281.4	744.7	3038	3490	1389	691.9	490.9
1953	401.5	327.0	308.9	302.3	273.2	278.5	342.3	973.1	3086	1427	551.2	408.5
1954	345.0	301.0	265.6	295.8	290.7	284.3	376.2	1572	1968	1195	521.4	391.6
1955	350.5	314.1	259.2	263.5	256.4	247.9	287.4	1036	2534	1050	486.5	397.0
1956	369.4	303.3	267.9	258.6	261.3	271.4	499.6	2628	3292	900.2	512.9	422.5
1957	375.9	323.0	299.7	287.4	292.3	273.0	315.0	1793	3309	1309	562.3	466.0
1958	417.9	340.2	305.9	306.8	330.6	300.1	371.4	2295	1948	795.1	508.9	421.2
1959	383.2	336.5	330.9	274.4	279.7	280.1	409.3	1124	4030	1378	733.3	731.3
1960	721.5	589.0	437.5	425.4	407.4	455.3	631.3	1463	2840	912.8	576.0	474.2
1961	419.2	351.8	304.9	309.5	313.6	320.2	351.8	1199	2213	657.6	471.1	586.4
1962	590.2	458.8	332.4	319.9	332.3	324.5	855.1	2164	3562	1599	781.3	582.6
1963	544.1	455.9	409.5	372.5	391.1	372.5	414.8	1709	3095	1151	593.7	566.2
1964	444.4	359.2	300.3	297.5	292.0	237.1	401.9	1779	3868	1618	718.7	535.3
1965	447.1	414.1	329.5	319.7	339.4	326.5	495.5	1603	4606	2453	906.0	682.6
1966	613.1	489.3	397.5	332.0	352.4	337.5	504.8	1939	2096	919.0	532.0	402.5
1967	416.6	373.5	312.3	305.2	311.2	320.2	374.1	1634	4202	2025	741.5	545.1
1968	549.7	442.5	351.6	335.2	333.8	377.4	432.7	1532	4730	2142	993.7	787.5
1969	637.4	521.2	414.2	365.9	373.1	362.2	734.1	2926	2602	1580	741.8	555.2

Table 3. Continue.

Year	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept
1970	*	437.8	*	*	*	*	*	*	*	*	*	*
1971	*	*	*	*	*	*	*	*	*	*	*	*
1972	585.3	437.3	389.9	303.5	379.3	437.0	486.4	1804	3533	1321	687.7	593.7
1973	603.6	469.3	350.9	336.0	345.3	329.3	401.6	1873	3261	1365	641.8	604.8
1974	515.5	463.3	392.2	334.6	339.9	388.1	640.0	1795	5056	1890	848.6	605.0
1975	519.9	447.4	399.4	392.5	367.9	372.1	394.6	1028	4157	3669	997.8	645.9
1976	698.7	521.1	438.3	392.4	373.9	375.3	598.5	3135	4194	1952	881.1	696.0
1977	599.1	476.3	390.5	341.2	347.3	336.1	670.9	1132	1995	712.3	465.5	449.3
1978	444.5	547.5	293.9	310.1	312.7	345.5	563.3	1638	3463	1904	700.5	610.9
1979	490.9	381.0	324.6	315.5	304.5	299.2	389.9	1673	2625	1073	572.9	409.0
1980	385.3	326.2	309.3	295.4	299.7	277.4	641.5	2305	2400	1107	599.1	547.1
1981	444.9	389.3	354.4	315.3	309.7	315.4	553.6	2193	3211	1169	581.4	465.6
1982	*	*	*	*	*	*	394.8	*	*	*	*	*
1984	*	*	*	*	*	*	*	*	*	*	*	*
1985	614.4	513.1	400.0	302.9	345.3	345.9	694.2	2048	1545	662.9	516.9	506.2
1986	465.5	351.8	317.5	328.4	323.0	374.5	663.4	1958	3691	1012	596.8	521.7
1987	463.2	379.6	305.6	309.2	293.6	302.4	550.8	1565	962.0	797.8	556.8	425.6
1988	304.3	307.1	271.3	263.5	258.9	279.7	603.2	2191	1909	620.7	412.9	364.3
1989	337.5	289.1	245.6	246.4	229.1	274.7	492.3	1587	2477	950.6	515.9	401.3
1990	415.1	350.3	263.1	269.7	253.2	297.2	599.3	*	*	*	*	*

* Indicates a no-value month

THE THUNDERSTORM

Objectives: Students will be able to:

1. Simulate the sounds of a thunderstorm.
2. Identify the sounds created by a thunderstorm.
3. Relate their own experiences with thunderstorms.

Background

This activity is a combination of "follow the leader" and an aerobic exercise. Prepare the students for this activity by stating that a thunderstorm is approaching their town. Ask your students to try and create a mental picture of an approaching thunderstorm and try to imagine its sights and sounds.

Thunderstorms are one of nature's most spectacular phenomena. In Montana, the thunderstorm season is from early spring through mid to late fall with a majority of the thunderstorms occurring in June, July, and August.

The sights and sounds that accompany a thunderstorm are impressive-bolts of lightning light up the sky, the rumbling sound of thunder, rain, wind and hail. For onlookers, there is usually much nervous anticipation when watching a thunderstorm approach. Will the storm be destructive? Does it have high winds? Will it hail?

Materials

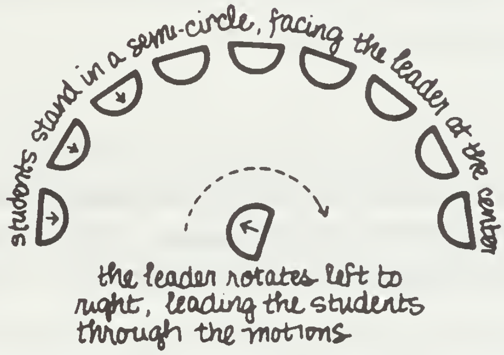
Energy

Activity

1. Ask your students to clear a space in your classroom. Better yet, go to the gymnasium if it is available.
2. Ask your students to form a half circle in front of you. Make sure all of the students can see you.
3. Begin this activity by asking your students to duplicate all the motions that you are about to make. Option: Have someone flick the light switch on and off at the peak of the storm.

4. Lead your students through the following motions:

- rub your hands together
- snap your fingers
- slap your hands on your legs
- stomp your feet
- slap your hands on your legs and stomp your feet
- stomp your feet
- slap your hands on your legs
- snap your fingers
- rub your hands together
- quiet.



5. Start on the left side of the half circle and slowly rotate to the last person on the right side. As you rotate from left to right, members of the half circle should begin to duplicate the leader's motion, either as he or she points in their direction or makes eye contact with them. This will cause a crescendo effect as you rotate from left to right. It will also cause a fade-in, fade-out of one type of sound to another.

6. When the last person is done rubbing his or her hands the activity is completed. This is a logical time to dismiss your class.

Closure

Have the students discuss what might be causing all of the sounds in a thunderstorm (i.e., thunder, rain or hail on the roof or hitting the streets, wind blowing the trees or driving the rain against the windows).

Have the students relate experiences they've had with thunderstorms (i.e., camping in a tent when a thunderstorm hits, collecting hail from the ground after a storm).

RAINDROPS KEEP FALLING ON MY HEAD

Objectives: Students will be able to:

1. Understand basic atmospheric science and terminology as related to water management.

2. Understand the importance of weather reports and forecasts to water management (e.g., drought and flooding).

3. Understand the important role that Meteorologists play in predicting water related natural disasters

4. Effectively utilize a weather report.

Background

Montana's weather patterns are caused by the state's continental climate. A continental climate is characterized by large and frequent temperature changes, light to moderate precipitation which tends to be irregular in time and coverage, low relative humidity, plentiful sunshine and nearly continuous air movement.

Predicting or forecasting weather is a difficult but very important task. The National Weather Service works with a network of regional, state and local groups to generate information for weather reports. Weather reports are broadcasted daily by radio, television, and newspaper.

A weather report has two general components. The first is the report itself. This contains information on what actually happened during a 24-hour period (7:00 P.M. to 7:00 P.M.). Information such as temperature, relative humidity, barometric pressure, wind and wind direction, and precipitation is given. Some broadcasts show photos or films of unusual weather occurrences of the day. All stations provide historical weather data to show record low, high and average precipitation and temperature.

A weather report also consists of a forecast. A forecast basically predicts what the weather could be like in the future. There are short-range forecasts that cover 24-hour periods, and long-range forecasts that cover longer periods of time (two to three days).

There is also a kind of forecast called an "outlook". An outlook is a very general forecast that is often used to discuss probable weather conditions for three or more days. An example of an outlook forecast would be: "the weekend weather outlook calls for mild temperatures with no significant precipitation expected."

Weather forecasts are predictions of future weather conditions. People rely on weather reports, forecasts and outlooks to plan their personal and work activities. Farmers closely monitor the weather conditions during spring planting and fall harvest. Fishermen, boaters, and campers rely on forecasts to decide whether or not a trip to a lake is in order.

Another type of forecast that deals with weather-related emergencies - floods, blizzards, severe thunderstorms and others -includes "weather watch" and "weather warnings". A "severe weather watch" means that the conditions are favorable for severe weather; however, severe weather hasn't occurred yet. A "severe weather warning" is given when severe weather has occurred. An actual sighting of a funnel cloud or, in the case of a winter "blizzard", zero visibility has been reported at your town.

COMMON TERMS USED IN THE WEATHER FORECAST: THEIR MEANING AND SIGNIFICANCE

Temperature:

Given in degrees Fahrenheit except for Canadian stations where they are given in degrees Celsius. To convert the Canadian temperature to Fahrenheit, multiply by 1.8 and add 32.

Relative Humidity:

A measure of how much water vapor (invisible gas) is in the air compared to how much water vapor the air could hold at that temperature. Thus, if the air contains one-half of the water vapor that it could contain at that temperature, the relative humidity is 50 percent. When the humidity reaches 100 percent, the water vapor begins to condense into liquid water and fog, or clouds form. As air gets colder the relative humidity goes up. As air warms, the humidity goes down. High humidity means clouds are more likely to form; they will tend to be larger, and precipitation is more likely.

Barometric Pressure:

A measure of how heavy the atmosphere is. Pressure is reported in "inches of mercury" meaning how much the air pressure can displace a column of mercury in a curved tube above the level point. High pressure usually means fair weather. This is because the air tends to be settling (moving downward) in a high pressure area. Thus, the air is being compressed and warmed, meaning the relative humidity is decreasing and clouds will tend to dissipate. In a low pressure area the air tends to be rising. Thus, the air is expanding, cooling, and the humidity is going up. Clouds and precipitation tend to form in such a situation. As an example...pressure greater than 30.00 inches of mercury would be considered "high".

Wind:

Wind direction is reported as the direction from which the wind is blowing. Thus, a west wind means the wind is blowing from west to east. A southwest, west, northwest, north, or northeast

wind usually means high pressure is moving into the area and a period of fair weather can be expected. Winds from other directions usually mean a low pressure area is approaching and that the chance of precipitation is increasing. Wind speed is recorded in miles per hour.

Precipitation:

Rainfall or melted snowfall is measured in inches, and in tenths and hundredths of an inch. The precipitation is usually reported as a 24-hour total up until 7:00 A.M. local time. This means that there might have been more precipitation during the day which will not be reported during the evening newscast.

Snow depth is simply the average of several measurements in different places using a measuring stick. The purpose of taking several measurements and averaging is to try to avoid drifts or places where the wind might have swept the ground bare.

Fronts:

A front is the dividing line between two different air masses. Fronts are actually elongated low pressure areas or "troughs". Usually one or more of the following features will change from one side of the front to the other: temperature, humidity, wind direction, and type of clouds and precipitation. Fronts are classified as "cold" if cooler air is advancing toward warmer air, and "warm" if the warmer air is advancing. A stationary front may shift position a few miles during the day but overall there is no "advance" of one air mass toward the other. An "occluded" front is sometimes mentioned. This is the "old age" portion of a front's lifetime which usually brings a slow moving, widespread area of precipitation. This type of front is a fairly rare occurrence in Montana and is much more common in the Great Lakes or New England region.

Since fronts are areas of low pressure, they affect the weather in the same way as a "low". Lows are areas of rising air where clouds and precipitation are most likely to form. In many cases they bring rapid and dramatic changes to the weather.

Precipitation Probability:

Many people are confused by the "30 percent chance of showers" part of the forecast. Does it mean that it will rain 30 percent of the time, or over 30 percent of the area, or what? Actually it means that, under similar weather conditions, it rained 3 out of 10 times in the past. A 0 percent or 10 percent chance seldom appears in the forecast. A 20 percent or 30 percent chance is quite common especially when summer thunderstorms are a possibility. If the chance of thunderstorms is 30 percent then it is likely that someone in the area will get rain, but it could very well miss many locations. The higher percentages are used when widespread rain is expected.

Materials

Paper
Marking pens
Seven-Day Weather Chart

Activity

1. Discuss Montana's climate. If your textbook has a section on weather and climate, have your students read it. Have your students brainstorm to develop a list of different kinds of weather that are common in Montana (rain, snow, high temperatures, blizzards, tornadoes, and others). How does Montana's climate affect your lifestyle? For example, in winter you tend to use more caution when traveling. How about the clothes you wear and the house in which you live?

2. Enter into another discussion on the subject of weather reports and forecasts. What is the difference between a report and a forecast? These are both part of the daily weather report. Introduce your students to the terms used by a meteorologist when giving a weather report. If you live in a town that has a radio or television broadcasting station you could invite the weather reporter into your classroom to talk about the importance of the weather report. This might be a good time to test your students on their understanding of the weather report terminology.

   Suggested reading: Weather, Boy Scouts of America, 1982.

3. Have your students make their own weather chart, using the Seven-Day Weather Chart form provided on the next page. Students should keep a careful seven-day record by listening to evening weather reports and forecasts.

4. At the end of the seven-day recording period, have your students prepare three graphs.

   Graph One - Daily Temperature - high and low

   Graph Two - Relative Humidity

   Graph Three - Barometric Pressure

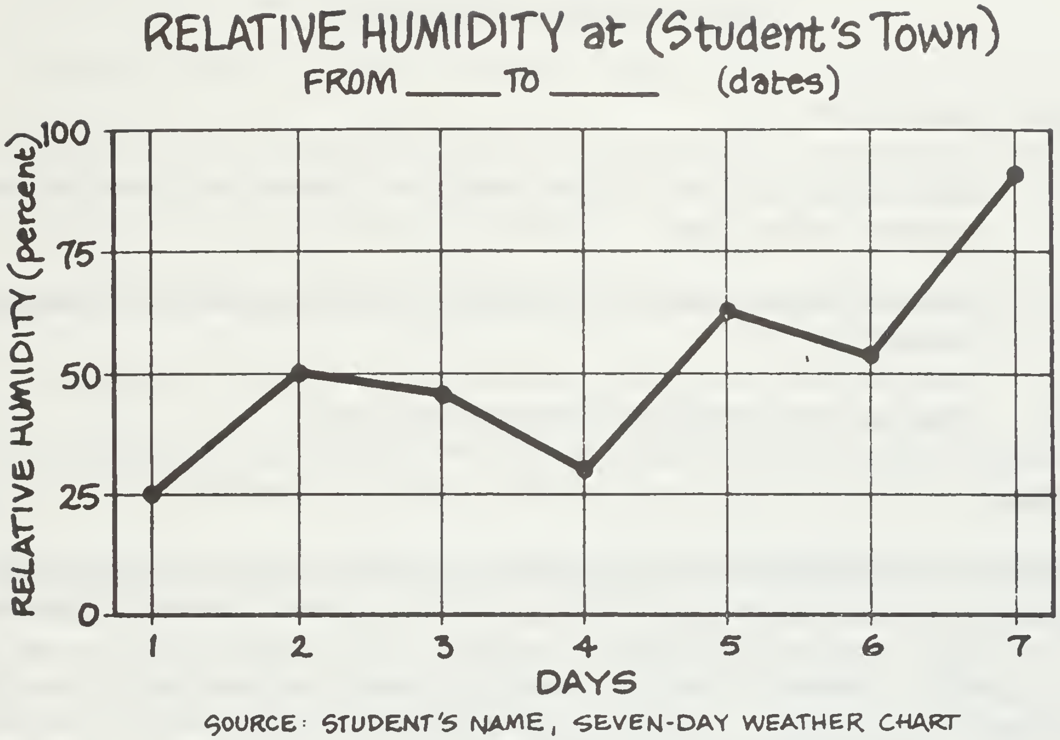
5. Have your students turn in their graphs and weather charts.

   Hypothetical Graph

   The graphs that your students prepare should have a title, the date the information was recorded, and the source of the information.

SEVEN-DAY WEATHER CHART

DATE	TEMPERATURE					CLOUDS		WIND SPEED (mph)	WIND DIRECTION	PRECIPITATION (inches)	PRECIPITATION PROBABILITY (%)	RELATIVE HUMIDITY (%)	BAROMETRIC PRES. (inches of mercury)	FORECAST	ACTUAL
	TODAY		RECORD												
	Hi	Lo	Hi	Lo	Ave	Yes	No								



Closure

Your students should have a fairly good understanding of the typical weather report, and the terminology used. Tell your students that they will now have a chance to write their own hypothetical weather report and forecast. Have each student select one kind of weather from the list developed during the first part of this activity. They should cover the same type of information a weather reporter includes in his or her nightly weather report. This means preparing a weather report that consists of existing conditions and a forecast. Have each student present his or her weather report to the class. The student giving the report should also give advice (if necessary) as to possible action that people should take for the particular weather condition the student is describing. For example, if the student is describing a tornado warning, his or her audience should be advised to take cover in a safe place because the tornado is rapidly approaching and has wind gusts of 50 to 75 miles per hour, large hail and deadly lightning.

Extension

Visit your local television or radio station to determine if they would be interested in having one of your students present a part of the nightly weather report. The student could be selected based on interest (enthusiasm) in this activity, knowledge of terms and the quality of the oral weather report.

Projects of public interest like this one are often well-received by the radio and television stations and draw favorable attention to your school.

WEATHER WISDOM

Objectives: Students will:

1) learn about some of the ways that people tried to predict and forecast the weather using only natural signs,

2) interview people to discover old sayings about natural ways of predicting the weather, and

3) create and write weather wisdom poems and essays.

Background

People were concerned about the weather many hundreds of years before the earliest radio and television personalities reported their first forecast. The pioneers' methods of predicting the weather, by today's complex meteorological standards, were primarily folklore and lacked scientific credibility. However, a person's interest in forecasting the weather was not a matter of choice, but of pure necessity. The weather determined when to sail, when to sow, when to harvest, and when to venture out into the wilderness.

The early pioneers learned to read nature's signs from their parents and friends, and from years of experience. Some of the weather sayings, which were popular in the past, might bring a grin to your face today. Here are a few common weather sayings:

If a dog eats grass, it is a sign it will rain.

Robins in the bush are a sign of an oncoming storm.

Fall is coming when the blackbirds start to bunch up in big flocks.

When people have aching joints, they say the weather is changing for the worse.

When the dew is on the grass, rain will never come to pass.

Cold is the night when the stars shine bright.

Some people believed that the weather on the last Friday of the month predicted the kind of weather for the next month. (i.e., Rain on the last Friday meant the next month would be rainy).

If the evening is red and the morning grey, it's the sign of a bonny, bonny day. If the evening is grey and the morning red, the ewe and the lamb will go to bed wet.

If the ants build up their hills, rain will from the clouds be spilled.

A hard winter is ahead when the buffalo berries are plentiful.

If a dog rolls in the snow, there is a storm coming.

When the Wooly Bear caterpillar's coat is thick and fluffy, a cold winter is ahead.

A ring around the moon means cold weather.

Red sky in the morning - sailor's warning. Red sky at night - sailor's delight.

An early, heavy coat on farm animals means a long, cold winter is ahead.

There will be an early winter if the geese and other birds bunch up and migrate south early. There will be an early spring if birds migrate north very early in the spring.

Measuring the spleen of a hog at butchering time would determine the length of the coming winter.

Rain will occur on the 3rd day, the 30th day, and the 60th day after a fog.

When leaves stay on the trees in the fall, it is a sign of a cold winter.

A snake on the road is a sign of rain.

There will be moisture 90 days after a heavy fog.

The bigger the beavers build their dams, the drier it will be.

It won't snow very long if there are large snowflakes falling.

When there are sun spots in the sky, there will be a change in the weather.

If a weasel gets white early, it will be an early winter.

If birds fly in groups near the ground, there will be a change in the weather.

When a person's arthritis flairs up, there will be a change in the weather.

It is a sign of rain when flies bite more aggressively than normal.

It is a sign of rain when cattle bunch together.

A lot of black caterpillars means a cold winter is ahead.

Rheumatism aches are a sign of a weather change.

When there is a sun dog (ring around the sun), a cold spell is coming.

When the corn husks are tight on the cob, a cold winter is ahead.. When the husks are loose, there will be an open winter.

If cream won't whip, a lightning storm will follow.

When we can hear noises from far away, it means moisture is on its way.

When wild ducks and geese make their nests far from the water, this means moisture is coming and the water will rise.

When you cut into an onion and milky-colored juice runs out, it means lots of moisture is coming.

When corn husks are thick, it is going to be a long, hard winter.

Crickets coming early means an early fall.

If the leaves stay on the trees, it's an indication of a hard winter ahead. (The leaves will provide the animals with something to eat.)

If it rains when the sun is shining, it is going to rain tomorrow.

Students acting up in school indicate a change in the weather is coming.

When muskrats build big houses, it's a sign of a hard winter.

When there are a lot of berries on the bushes, it's a sign of a hard winter. (The berries will provide both animals and human beings with something to eat or store for the winter.)

If the sun goes down clear on Friday night, clear weather will prevail throughout the week.

A rain is coming when lots of ant hills are seen on the roadside.

If the "big dipper" holds water (not tipped) it won't rain.

If the dull sides of leaves on trees are showing, it will rain.

If the moon is tipped, it will rain.

A high-flying flock of geese heading south led some people to believe that cold weather was on its way.

On New Year's Day, some families cut an onion in half and pulled out 12 onion bowls each representing one month) and filled the bowls with salt. If the salt in any or all of the onion bowls was wet, it meant that month would be rainy.

These are just a few of the hundreds of weather sayings people once used to predict the weather. Your class will no doubt generate many new and interesting sayings in their class project.

Materials

Paper and pencils
Art materials

Procedure

1) Introduce this activity by asking your students to think of some of the ways that people know when the seasons are going to change or when the weather is going to change. What are some of the clues to the changes? (i.e., trees lose their leaves and birds start to migrate south.) Explain that these and many other signs from nature were used by people to predict and forecast the weather. The weather signs were often developed into weather sayings.

2) Explain that most of the weather sayings were created long before modern meteorology and that the signs or feelings about the forthcoming weather were important.

3) Assign each student the task of interviewing someone (i.e., parents, aunts, uncles, grandparents, or older friends) to try to discover some old weather sayings. The weather sayings should be written down on a piece of paper and reported to the class. Discuss the basis for each saying. What gave the sign? (i.e., animals, clouds, people, vegetation, stars, etc.) Do you think the weather sayings were reliable?

4) Each student should create an original drawing depicting one of the weather sayings the class discovered. Display the drawings and the weather sayings on the classroom bulletin board.

5) Have your students brainstorm a list of reasons why timely and accurate weather reports and predictions are important. Ask them to think of some of the ways that forecasts help people. Use this example; "If a river is almost ready to flood and the forecast is for more rain in the river's watershed, there is reason for floodplain managers to warn people of rising waters and potential danger."

Extension

Develop a weather forecast based on the weather sayings your class developed.

DROUGHT DAYS

Objectives: Students will:

1. study how drought impacts water use,
2. learn about practical methods of conserving water, and
3. understand the circumstances that cause people to ration water.

Background

The average daily water consumption per household in the United States is 200 gallons per day. This might seem like a lot of water; however, when you think about the amount of water used to flush the toilet, wash the dishes, or wash the clothes, it is easy to see how a family of three or four can use 200 gallons of water.

Household water consumption is at its highest during the summer months. People use more water for watering their lawns than any other summer use of water. Swimming pools also require a lot of water. During the summer the household water use could easily exceed 300 gallons per day. Household water consumption is at its lowest during the winter. The household water use will dip to the 100- to 150-gallons-per-day range.

There are many variables that affect the amount of water consumed by a family. A few variables include: the size of the family, the occupations, the number of bathrooms, the importance assigned to a green lawn, and/or the presence of a garden.

Weather is the single most important factor determining water use. Most community and rural water systems are designed to meet abnormally high water needs during short periods of hot and dry weather. When hot and dry conditions persist and water users consume even larger quantities of water, a water system may reach a point where it can no longer meet the demand. Some uses of water may have to be reduced or even eliminated.

Water rationing is common in drought-prone regions of the country. Water system managers know the quantity of water their systems can deliver. If ground water is the source, the water plant manager will know the quantity of water each well in the city's well field can safely yield. If the source is a river, the volume of water flowing in the river will dictate the availability of water. If there is no water or very little water in the river or if demand exceeds the yield capacity of the city's wells, a serious water shortage can occur.

The capacity of the water delivery system to deliver water also plays an important role in determining if water rationing is necessary. For example, most communities have water treatment plants. Water is pumped from the source (wells or river) to the water treatment plant where water is made suitable for people to use and to drink. Water treatment plants have a maximum capacity that can be treated in a given period of time. More water cannot be treated unless the plant is expanded, an expensive undertaking requiring public funds.

Water towers and reservoirs are also part of the delivery system. These storage facilities can only store so much water at one time. High water use can drain water storage reservoirs faster than the treatment plant can replenish the water. This cannot be allowed to happen for many reasons including fire protection needs.

When water rationing is required, the city council, with guidance from the water plant personnel, will target the major nonessential uses of water such as lawn watering. Often homeowners will be asked to water their lawns on alternating days. This will usually significantly reduce the demand for water.

If there is a need to further reduce the amount of water being consumed, the city council may ask the public to cut down on household water uses. This means reducing the amount of water a family consumes. How this could be accomplished would be outlined by the city. Some suggestions might include installing water-saving shower heads, placing a brick in the toilet tank, and washing clothes less frequently. Your class will be able to think of other water-saving ideas.

Farm and ranch families and other people who live in rural areas also have to cope with water shortages. If a family gets its water from a rural water system, it will be under the same restrictions that apply to city water systems. The rural water system manager, with guidance from the system's board of directors, will ask water users to cut back on use during certain times of the day. If a farmer or rancher has his own well, he must make a personal decision to reduce water use. If the farm's well runs dry, the farmer will be forced to haul water. This is usually a last resort; however, hauling water is not uncommon in Montana. Other options may include hooking up to a rural water system.

<u>Past Household Water Uses</u>: In 1890 the average household would not have consumed 200 gallons of water per day. Using water required a great deal of work. Water was often pumped from a well and hauled by bucket to the house. The idea of hauling 200 gallons of water by bucket for household use would have been considered ridiculous. Some homes had cisterns which stored water that drained from the roof or was hauled in by tank or bucket. People used only the amount of water that was absolutely necessary.

Think about ways a person would use water in 1890. A mother would use water to wash clothes, bathe the children, wash the dishes, and cook food. Not only did people have to haul the water into the house, they also had to haul the used water back outside.

We use water in many of the same ways today. The main difference is, in 1990, most homes have running water and many "water-hungry" appliances (i.e., dishwasher, clothes washer, and garbage disposal). People use more water in 1990 because it is a lot easier to use. Just turn on the faucet and out comes the water; there is very little work involved. We have made a decision as a society to pay for the convenience of having water at our finger tips.

Procedure

1. Review the circumstances that cause city water departments to call for reduced water use. This should include a discussion about droughts and the fact that most water systems can only deliver a limited amount of water per day to city water users.

2. Give each student a copy of the Drought Days Simulation -Situation 1 worksheet. You can either have each student complete the worksheet individually, or have them form family groups. Encourage your students to role play the different family members if groups are formed.

3. After your students have completed Situation 1, list the suggestions on the blackboard. (See activity "Who Uses H_2O?" for the amounts of water used by toilets, dishwashers, etc.)

4. Ask your students to complete Task 2. Again review and discuss their suggestions. It might be meaningful to calculate the cost of the water at this time.

   (31 days x 300 gallons per day = 9300 gallons for the month of July. 9300 divided by 1000 = 9.3, 9.3 x $4.25 per 1000 = $39.52 per month for water.) Calculate the monthly water bill for: 1) July without a reduction in water, 2) July with a 75-gallon-per-day reduction, and 3) July with a 150-gallon-per-day reduction. Your students will no doubt tell you that you only save a little money ($10.00 per month in Situation 1 and $20.00 per month in Situation 2). Explain that the rationing is not being done to save money for families; it is being done to conserve water. Have a group calculate how much water was saved during the month of July in Situation 1 and then in Situation 2.

   The students could then calculate how much water they saved collectively.

5. Next have your students complete Situation 2, Task 2. Tell your students that they will study water uses of 1890. It will be important to point out that electricity and indoor plumbing were not available. Remind your students that conserving water was the rule and not the exception in 1890. Review, discuss, and contrast Situation 1 (1990) with Situation 2 (1890).

Extensions

1. One of the biggest reasons households used so little water in 1890 was that someone had to pump the water into a bucket and haul it to the house for use. This required a lot of time and hard work. Your students will more than likely not be able to relate to the hard work because using water today is so easy.

   To reinforce your students' understanding of the work involved, set up an experiment where your students have to haul an "imaginary" 200 gallons of water using equivalents (i.e., one cup = one gallon or one gallon = 5 gallons). Remind your students that not only would they have to haul the water in 1890, they would also have to pump it from a well.

   Your students will have a great deal of fun with this activity. In an attempt not to waste water, haul the water to a tree.

2. Have each student find out how much water his or her family consumed during the past two or three months and then calculate how much each family paid for the water. (Note: This will only work for families who have a water meter and pay a monthly or quarterly water bill.) Calculate the average daily water use per family member. How does this compare to the national average water consumption of 75 gallons per person per day? Find out which student(s) consumed the most water per person and per family. List the results on the board. Discuss the ranges.

<u>Drought Days Simulation</u>

Student Worksheet

1990 Family

Situation 1. <u>Date 1990</u> You are a family of four: two adults and two children - a 16-year-old girl and a 13-year-old boy. Your family lives in a newly developed subdivision of a growing town. Your house has two bathrooms and every modern convenience available (i.e., a dishwasher and clothes washer). You have a swimming pool, a large manicured yard with a watering system, a flower and vegetable garden. Your family has three cars and a motor home. Your family's water consumption averages 300 gallons of water per day during the summer.

<u>Task 1.</u> The town in which you live is beginning to experience a water shortage because of heavier use caused by persistent hot and dry weather. You have just been notified by the water department that each household must decrease water consumption by 75 gallons per day. As a family, decide how you will deal with the request. First, make a list of all of the ways your family uses water. Then, list five changes you will make in your water use habits.

Household Uses of Water ____

____

Five changes ____

____

<u>Task 2.</u> It is now two weeks later. The hot and dry conditions continue to plague your town. The water department has asked each household to decrease household water consumption another 75 gallons per day. Below, list an additional five changes you would make in your water use habits.

Five changes ____

____

<u>Task 3.</u> How much would your family pay for water if they paid $4.25 for every 1000 gallons consumed?

July with no change in water use: ________

July with a 75-gallon-per-day reduction: ________

July with an additional 75-gallon-per-day reduction: ________

Drought Days Simulation

Student Worksheet

1890 Family

Situation 2. Date 1890. You are a family of eight persons: two adults and six children - a 9-month-old boy, a 3-year-old girl, a 6-year-old boy, an 8-year-old boy, a 10-year-old girl, and a 15-year-old girl. You live in a tar paper house with three rooms.

You get your water from a well located 150 feet from your house near the barn. Your dad recently dug a pit for an outhouse. Your family has five horses (12 gallons of water per horse per day), two hogs (3 gallons per hog per day), and four cows (12 gallons per cow per day). You also rely on a garden for most of your family's vegetables.

Task 1. You have noticed that the well is not able to meet your family's water needs during prolonged periods of hot and dry weather. If the weather conditions persist, you will have to decrease your water consumption or take some other kind of action.

List all of the ways your family uses water. Remember, there was no running water or electricity in your house in 1890.

____

Task 2. How much water do you think this family of eight would consume in one day? ________ If the family had to decrease water consumption, how would they do it? Please list your ideas below.

____

Why do you think the well was dug closer to the barn than to the house? __________

How much water would your livestock consume? __________

Task 3. Do you think the average household in 1890 would consume 200 gallons of water per day as the average household does today? List several reasons why they would or would not use 200 gallons of water per day. (This does not include water for livestock.)

____

____

WATER VALUES

Objectives: Students will be able to:

1. Examine their own values and beliefs related to water issues.

2. Evaluate possible actions they might take that have an impact on water in the environment.

3. Examine, express, clarify, and take responsibility for their own reasoning.

Background

The water resources that we have in this semi-arid climate are precious. The well-being of our state is closely tied to adequate supplies of water. Farmers and ranchers depend on precipitation to grow their crops and to raise livestock. Our cities and towns need dependable sources of water to meet their increasing water needs.

Meeting our state's water needs on a year-in year-out basis represents a difficult task. There are many reasons for this. Foremost is the different water values that people hold. To what extent a person values water has a great deal to do with:

* **Upbringing** - A person's past has a lot to do with the way he or she values water. Did your parents have ample supplies of water or did they have little? Did they ever live in an area where a drought occurred? A person who has experienced a drought will no doubt have a different value than someone who has not.

* **Occupation** - Some professions are more dependent on water than others. For example, the success of Montana's number one industry - agriculture -is closely tied to receiving adequate amounts of moisture at the right times.

* **Location** - Certain areas are more prone to water problems than others. For example, if you live in the low lying area along a river and experience a flood and your house is flooded, you will have a greater appreciation for floods.

* **Presence or Absence of Modern Day Conveniences** - Technological advances have had a great deal to do with the improvement of our quality of life. An example of how we have improved our quality of life is the change from hauling water by bucket to running water and indoor plumbing.

Your students will have other ideas that should be written on the blackboard for discussion.

As stewards of our natural resources we have an obligation to manage the resources to the best of our abilities. This means weighing the good and the bad points of any action. At a personal level you are faced with hundreds of choices that reflect your water values. For example: you can build a septic system at your lake front cabin or you can leave the present system that is polluting the lake. What do you do? What types of things will you consider when making your decision?

Materials

Dilemma Cards - photo copy pages that have dilemmas on them and cut into individual dilemmas.

Activity

Students will read, discuss, make judgements, and write about hypothetical dilemmas concerning water issues and natural resources in Montana. They will talk about water resources as being important to our communities, to rural water users, and to other water interests, and how each of us will be asked to make more and more personal choices on water use and water conservation.

* Copy and cut up the dilemma cards, then paste on 4" x 6" cards. The students can also create their own dilemmas on the blank cards. There should be one card for each student.

* Divide the students into small groups. Have the students put their cards in a pile, face down, in the center of the group.

* Each student takes a card and reads it silently, Give the students several minutes to study the situation and decide what they would do and why. After the time is up, have each student read his situation and options aloud to the rest of the group. The student then gives the option he or she has chosen and why.

* The rest of the players decide to what degree each agrees with the other player's answer. Rating is done on a scale of 0-10. Zero is total disagreement and 10 total agreement with the decision of the player. A rating of 5 means "no opinion" or "needs more information".

* Each player is given a chance to announce how he or she rates the other player's decision and give the reasons why. The person being rated should have the opportunity to ask questions and offer clarification. Ratings should not represent a judgement of the person but a way for students to experience having ideas examined by peers. The ultimate purpose is to provide the students with an opportunity to examine, express, clarify, and take responsibility for their own reasoning.

* Continue the process until all players have had a turn.

Closure

One member of each group could report on the most controversial dilemma the group discussed and the class as a whole could informally evaluate the option that was selected and provide alternatives that might be better.

Conservation restrictions (such as rationing) could be discussed. Merits of various plans could be evaluated.

Evaluation

Determine if objectives have been met by listening to the discussion.

Have students examine their values and beliefs.

Have they made judgements on the options according to merit or the personalities involved?

DILEMMAS

DILEMMA 1. You have changed the car's oil. WHAT DO YOU DO?

1. Put the oil in the back of your garage?
2. Place it in a garbage can for disposal in the city/county landfill?
3. Pour it on the ground someplace out of sight on your land?
4. Burn it?
5. Take it to an approved disposal container several miles from your house?
6. Other?

DILEMMA 2. You have one gallon of water to last you one week. HOW WOULD YOU USE IT?

1. Ration some for yourself each day for drinking only.
2. Share with your dog or cat.
3. Water your dying plants with some.
4. Learn how to gather some more from the air condensing on the underside of a closed plastic covered container in the sun and use that for your plants and animals.
5. Other.

DILEMMA 3. You and a friend are out hiking and you see someone dumping a 55 gallon drum of what may be a hazardous material into a wash. WHAT DO YOU DO?

1. Go over and ask what is going on.
2. Run home and call the police.
3. Wait until the dumper leaves, then go investigate by smelling and feeling the chemicals.
4. Take down the license plate number and then report it later to the fire department.
5. Other.

DILEMMA 4. You are the Governor of Montana. Streams that are used to irrigate crops are drying up impacting fish populations and reducing recreation opportunities. WHAT WOULD YOU DO:

1. Ask irrigators to stop irrigating?
2. Ask fishermen and women to recreate at larger rivers?
3. Establish a committee to study the problem?
4. Propose to build a dam and reservoir to store water for release when needed?
5. Purchase or lease irrigated land along the stream to eliminate the water use?
6. Establish a water conservation program with incentives?
7. Check historic streamflow records to determine if the stream has ever had water in it in the fall?
8. Other?

DILEMMA 5. You are walking to your class and you see that one of the sprinklers on the school grounds has broken and is spraying a stream of water across the sidewalk and onto the nearby street. DO YOU:

1. Put your finger in the sprinkler to stop the spray and send a friend to report the leak to the office.
2. Tell your teacher about the leak?
3. Report the leak to the custodian?
4. Send an anonymous letter to the principal?
5. Walk carefully under the water to keep from getting wet?
6. Other.

DILEMMA 6. Your city is running out of water and everyone will face severe conservation restrictions. WOULD YOU CHOOSE TO:

1. Ban the building of private pools.
2. All watering of lawns and golf courses must be limited to 15 minutes three times a week.
3. Ban all car washing.
4. All households are restricted to 30 gallons per person per day. (Average daily water consumption is 150 gallons per day per person.)
5. Other.

DILEMMA 7. You own a cabin on a lake that is 100 miles from your permanent home. There are 400 other cabins on this lake. Sewage from your cabin is moving from your septic system's drain field, through the ground, into the lake. You have been notified by a local health authority that the lake's water quality is poor, and weed, algae and odor problems could result because of the septic system problems. WHAT DO YOU DO?

1. Sell the cabin.
2. Ignore the problem by doing nothing. (Attitude: this is someone else's problem.)
3. Have your sewage pumped and hauled to a safe place.
4. Form a lake association and try to resolve the problem.
5. Other.

DILEMMA 8. You are the mayor of a city which has an area known to flood. A developer wants to build five new houses in this flood area. DO YOU:

1. Inform the developer no building will be allowed.
2. Let the developer build in the flood area.
3. Insist the developer elevate the houses on fill in hopes of avoiding flood damages.
4. Instruct the developer to find an alternative building location out of the flood area.
5. Other.

DILEMMA 9. The well on your farm does not yield enough water to meet your domestic and livestock water needs. WHAT DO YOU DO?

1. Haul water in by tank, truck, or wagon.
2. Sign up for the new rural water system that is proposed for your area.
3. Drill a new well in an attempt to find a better source of water on your property.
4. Reduce your farm's water consumption to an amount less than your well's yield.
5. Other.

CHOICES, PREFERENCES, AND TRADE-OFFS

Objectives: Students will be able to:

1. Decide which types of water usage they feel are most important.
2. Understand which choices of water usage their families make.
3. Graph the information gathered.

Materials

Copies of water usage choices.

Butcher paper for graph.

Background

This activity is to be done before students have studied supply and demand of water or before they have discussed conservation. It is similar to an exam one would take to determine their interests and vocational preferences.

Introduction

Explain that this is an activity that students should do individually first and then repeat in groups. Families are encouraged to participate also. Graphing skills are featured. Discussion is the basis of this activity.

* Hand out the lists of 20 water usage choices. Give the students five minutes to prioritize their choices by assigning the highest number (20) to their first choice, and on down to the last choice (1).

* Divide the students into groups of five each and have them combine their choices. Designate one person in each group to act as the leader. This person will calculate the rankings. Another member of the group should draw a bar graph on the butcher paper. Each group should hang their bar graph on the wall and compare the results with the other groups' bar graphs. How do they differ? How are they similar. The usage choices should be graphed in order from the highest to the lowest value.

* Using the butcher paper, graph the combined water use preference of all groups on another bar graph.

* Have the students take a survey at home. Ask their families to rank their choices of the same list. Have them bring the surveys back the next day.

Closure

Have the students decide what the reasons were for the choices they made. Was it difficult to decide? Would they have done it differently if they really had to make personal choices about a limited supply of water? Which of the 20 choices are water for survival?

Evaluation

Have the students discuss their own choices at the beginning of the activity with the graphs showing the personal choices of the other students and of their families.

Extension

Have students brainstorm ideas for a list of other kinds of water uses that relate to broader use categories. Have your students prioritize the following list and explain thier choices.

1. Water for recreation
2. Water for livestock
3. Water for irrigating crops (corn, soybean, etc.)
4. Water for human consumption in towns
5. Water for energy development
6. Water for fish
7. Water for human consumption on farms
8. Water for wildlife
9. Water for transportation (barge for hauling grain)
10. Others

WATER USAGE CHOICES

*Student's Name*_________________________ *Date*__________________________

Directions: Assign Values in this manner:
First Choice = 20 Second Choice = 19 Third Choice = 18 Last Choice = 1

___ Swimming Pool
___ Drinking
___ Bath/shower
___ Brushing teeth
___ Washing clothes
___ Washing dishes
___ Washing car
___ Washing dog
___ Flushing toilet
___ Cooking
___ Watering vegetable garden
___ Watering trees and bushes
___ Watering grass
___ Making ice cubes
___ Filling bird bath
___ Filling and maintaining an aquarium
___ Shaving
___ Washing hands
___ Watering house plants
___ Maintaining water in a decorative water fountain

ASSIGN VALUES
IN THIS MANNER:
first choice: 20
second choice: 19
third choice: 18...
last choice: 1

Questions:

1. *What was your most important use of water? Why?*

2. *What is the least important use of water in your opinion? Why?*

3. *List several factors that would influence your decision to conserve water?*

"WATER DOWN THE DRAIN"

Objectives: Students will be able to:

1) understand that a leaking faucet can lose a great deal of water,

2) relate the amount of water lost over time (day, month, year) to dollars lost down the drain, and

3) discuss the importance of wise water use.

Background

Water leaks cause big problems to rural water systems, communities, households and other water users. Every year millions of gallons of water are lost through leaks. If a leak is underground, as is the case for rural and community water system lines, the leak could go undetected for a long time, and, in the process, cost the water system or water user money.

For example, when developing a water system, project planners will calculate a 10 to 20 percent water loss factor to adjust for unaccountable losses (leaks). This means that a water system would be able to lose 10-20 percent of its water in unaccountable ways and still have enough water to meet water needs.

The amount of water that can leak from a faucet or toilet over a day or week is sometimes quite sizeable. A 1/32 inch leak wastes 25 gallons in one day. A 1/16 inch leak wastes 100 gallons in one day. A 1/8 inch leak wastes 400 gallons in one day. It is easy to see how a great deal of water can be lost in a short time.

Leaks cost water systems (the people that sell water) and water users money. For example, if your faucet leaks 100 gallons a day for one month (30 days), 3000 gallons will be wasted. If your water costs $3.50 per thousand gallons of water consumed, you will pay 10.50 more on your monthly water bill than you would pay without the leak.

Materials

* Container to collect water
* Stopwatch
* Water faucet
* Gallon or quart container of water (Ice Cream Bucket)

Activity

1. Demonstration. Display a one gallon container of water in front of your class. Explain that the water in the container was collected from a leaking faucet. To illustrate this point, turn on a faucet just far enough to get a steady drip. Ask your students to observe the dripping faucet and then estimate how long they think it would take to fill a one gallon container and how many drops of water it would take. Teacher should have calculated the results prior to the classroom demonstration.

   Compare the students' estimates against your results. Explain that the size of the drops, frequency that the drops occur, and the length of time that a faucet is allowed to leak all affect the amount of water wasted.

2. Laboratory Exercise. Ask your students to pair up with their lab partner. One of the pair will count drops, while the other student times the experiments. Hand out the leaking faucet data sheet that is located on the next page. Have your students complete part one, description of leak and part two, experiment results. The smaller the container the faster this experiment can be run.

   Have the students return to their desks with the above information.

3. Classroom Exercise. Ask your students to use the data that they collected in the laboratory exercise to complete part three of the data sheet. Explain that water has an economic value and that most people in Montana have to pay for water. Water is often sold at a dollar amount per 1000 gallons (i.e. $2.00 per 1000 gallons, $3.50 per 1000 gallons).

Closure

Ask your students if they were surprised by the large amount of water that was wasted by the leaking faucet. Ask them if the amount of money surprised them. Could they have used the money lost down the drain for something of value? Lead a discussion on the importance of stopping leaks.

Leaking Faucet Data Sheet

Part One - Description of Leak

Part Two - Experiment Data

1. Number of drops per minute (average of three readings)

Readings	1st	2nd	3rd	Average
No. of Drops	____	_____	_____	_____

2. Interval of time between drops _____ seconds
3. Amount of water collected in one minute (average of three readings)

Readings	1st	2nd	3rd	Average
No. of Drops	____	_____	_____	_____

4. Amount of time it takes to fill container (for a slow leak, measure with a graduated cylinder one gallon of water equals 3785 milliliters): _____________

Part Three - Water Wasted

Time	Total Number of Drops	Weight of Water Wasted (ounces, pounds*)	Total amount of water wasted (gallons)	Total cost of water wasted (3.50/1000 gals.)	Cost of water wasted per gallon
1 hour					
1 day					
1 month					
1 year					

*One gallon of water weighs 8.34 pounds.

Evaluation

Grade the data sheet.

Extension

1. Create word problems for your students to calculate.

   Example: You have a faucet which drips at the rate of 80 drips per minute. If 1000 drips equal one 8-ounce cup, how long will it take for the faucet to leak one gallon of water? How long to leak one cubic foot of water (one cubic foot equals 7.48 gallons)?

   Answer: 1000 divided by 80 = 12.5 minutes/cup x 16 cups = 200 minutes/gallon

   200 minutes = 3 hours, 20 minutes

   200 minutes x 7.48 gallons/cubic foot =
   1496 minutes (24 hours, 56 minutes)

2. Take a field trip to your local water utility - have a person at the utility talk about the water they treat, its costs and the problem of municipal water leaks. Have your students compare the amount of water leaked from the laboratory exercises (1 hour, 1 day, 1 month, 1 year) against the amount of water stored in the municipal water tower or storage reservoir.

WHO USES H_2O?

Chapter Reference : Water Works
Grades : 7-8
Subject : Math, Science
Duration : One or two class sessions
Key Vocabulary : Conservation
Credits : Adopted from A Sense of Water: Southern Arizona Water Resource Association

Objective Students will be able to:

1. Understand how their family's water use compares to the average figure of the student's municipal or rural water utility.

Background

Water use rates among different households can vary enormously. The figures normally given for use levels are the averages for single family residential users serviced by the municipal or rural water utility. These averages are also variable - they have peak hours, peak months, and can vary year to year.

Factors which influence these figures include: working and school schedules, weather, conservation practices, and number of people in household.

You will find representative figures for the amount of water used in household activities in the following list.

Closure

Have a discussion of how much water use each person can control individually.

Have them identify where they think their family can cut down the water they use. Focus on any "surprises" students may have had after analyzing their water use and the variables that influence it.

Evaluation

Have the student keep track of how much time he/she spends using water at home for a week, i.e., 1 1/2 hours a day engaged in activities using water (10 minute shower, 3 minutes brushing teeth, etc.).

DAILY HOUSEHOLD USE

	Typical Use	Assuming	Conservation Use	Assuming	Your Use
Toilet Flushing	25 gallons	5 flushes at 5 gallons per flush	20 gallons	Use tank displacement; 4 gallons per flush	________
Shower, Tub Bath	28 gallons	5 minutes at 6 gallons a min.	4 gallons	Low Flow device. Wet down, soap up, rinse off	______
Lavatory	3 gallons	Tap running	1 gallon	Fill basin, Wet brush, rinse briefly	________
Washing dishes (automatic dishwasher)	15 gallons	5 gallons per 3 loads		Short cycle; try always to wash full load	_____
Laundry	18 gallons	6 gallons per 3 loads		Try to always wash full load; adjust water level to reflect amount of clothes	________
Sink, Misc.	3 gallons	For basic human needs	2 gallons		________

Materials

* Water use records from students' families (amounts can be obtained from the monthly water bill)
* City figures
* graph paper
* rulers/markers
* School water use figures (You can use your own use records for a backup)

Have students "guess" how much water they use. During the discussion of how much water students think they and their families use at home, their attention should also be directed to the fact that some activities require more water than others. For example, on average, about 40% of all residential water is used outside - primarily in landscape irrigation and pools, and inside the house 75% of the water used is in the bathroom. Students should consider where the greatest conservation potential is.

Making Line Graphs

Have the students bring in their use figures and graph out the past 12 months. (If none are available, use your home figures.) Have them draw in the average supply family use line across the graph. Have the students graph in their own water usage on another graph. Here is an example of what the graph of the city of Bozeman looked like in 1989. Compare, analyze, interpret data.

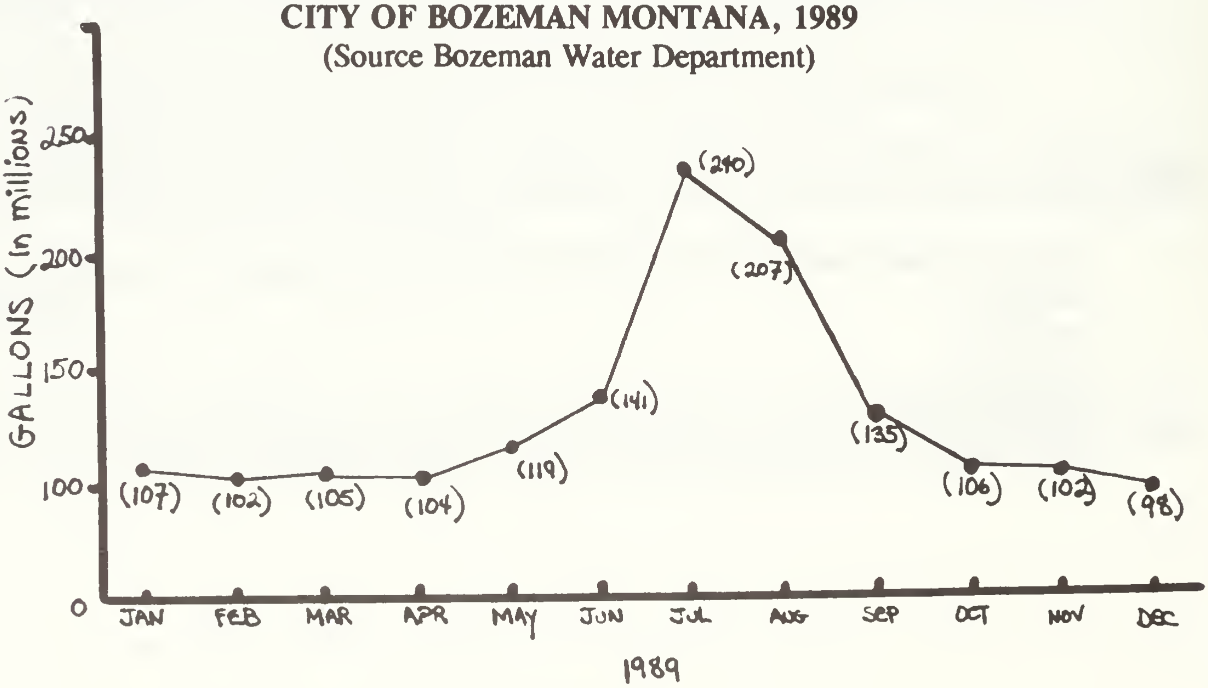
Compare the peaks and valleys in the graphs. Do they fit the pattern? Analyze - Why or why not?

In comparing these figures and graphs, consider the following factors and how they may relate to water use:

* Different times of the year
* Number of people in the household
* Size of family yards
* Age of family members
* Schedules of family members
* How water conscious the family is and how much they practice water conservation

GRAPH OF AVERAGE MONTHLY WATER CONSUMPTION FOR THE CITY OF BOZEMAN MONTANA, 1989

(Source Bozeman Water Department)



COMMUNITY "CUPLINKS"

Objectives: Students will be able to:

1. Identify their community's water supply and distribution system as a significant component of the community.

2. Recognize the importance of a dependable water supply to the wellbeing of their community.

3. Determine the significance of the loss of their community's water supply.

Background

Montana has 139 communities which range in size from the small towns, that have less than 100 people and up to the state's largest city - Billings, which has a population of 80,300. In 1986, Montana's urban population was estimated to be 376,000 or 46% of the state's total population.

An important component of any community is its water supply and distribution system. A dependable water supply that can meet water needs during the high demand periods (summer) and is capable of handling the growing water needs of an expanding population is essential to a community's well-being. Equally important is the condition of the distribution system. A distribution system includes a well or well field; a water treatment plant (not all towns have a treatment plant); water storage facilities (water tower or reservoirs); water mains; pump stations; and feeder lines to users (houses, businesses).

Other important components of a city include: a transportation system (streets, traffic lights, sidewalks, etc); an energy distribution system (electricity and petroleum); a communication network (TV, radio, telephone, written material, etc); and a waste disposal system (landfill, sewage treatment plant, etc).

When the community's system is operating properly without any problems, the residents often take the individual components of the system for granted. For example, they take for granted that they will have water for all of their needs. When a problem occurs such as a broken water main, well problems, well contamination and others, people begin to realize the importance of water. What would you do if there was no water to shower in the morning or wash your clothes? How would not having water for a day affect you?

Materials

None needed.

Activity

1. This activity takes very little time - but has a lot of impact! Ask the students to number off from "one" to "four". All the "ones" go to one corner of the room, the "twos" to another, etc.

2. Ask the students move to their corners, clear a space in the center of the room. Better still, go outside to a clear, grassy area. The "ones" should sit or stand together, "twos" together, etc.

3. Assign each group a concept as follows:

   ones" = water, "twos" = energy, "threes" = waste disposal, "fours" = communication network.

4. Now, it's time to form a circle. This is done by building the circle in chains of water, energy, waste disposal, communication network. A student from each of the four groups walks toward the cleared area. The four students stand next to each other, facing in toward what will be the center of the circle. Four more students - one from each group - join the circle. Keep adding to the circle in sets of four until all the students are in the circle.

5. All students should now be standing shoulder to shoulder, facing the center of the circle.

6. Ask the students to turn toward their right, at the same time taking one step toward the center of the circle. They should be standing close together, with each student looking at the back of the head of the student in front of him or her.

7. Don't panic - this will work! Ask everyone to listen carefully. Everyone should place their hands on the waist of the person in front of them. At the count of three, you want the students to sit down...on the knees of the person behind them, keeping their own knees together to support the person in front of them. You then say, "water, energy, waste, and communication, when functioning properly (represented by the students' intact, "lap-sit" circle) - are what are needed to have a stable community."

8. The students at this point may either fall or sit down. When their laughter has subsided, talk with them about the necessary components of a community.

9. After the students have discussed and understood the importance of water, energy, waste treatment and a communication network to a community - let the students try the circle activity again. As the students lap-sit, still representing the same components of their community - identify a student who represents "water". Then say, "It is a drought year; the water supply is reduced by the drought conditions". At this point, have the students who are called "water" remove themselves from their positions in the lap-sit circle - and watch the circle collapse, or at least suffer some disruption in arrangement...You could try this in several ways - removing one or more students from the circle. Conditions

could vary: pollution of water supply, urban sprawl limiting availability of all components, soil erosion impacting food and water supplies, etc.

Since people need water, energy, waste disposal, and a communication network to maintain this present quality of life, the removal of any component will have an impact.

Closure

Ask the students to talk about what this activity means to them. Ask the students to summarize the main ideas they have learned. For example, the importance of a dependable water supply and distribution system. Or how the loss of any one of the components mentioned would impact the community. What would happen to the town?

Evaluation

Ask the students to list the four components - water system, energy system, waste disposal system, and communication network, and explain why they are important.

Have the students explain what life would be like without one of the four components. What types of changes would take place? Could we survive?

WATER WORKS

Objectives: Students will be able to:

1. Understand that water is an essential element of our lives.

2. Understand that it takes water to manufacture goods, to produce agricultural products, and to provide just about any other kind of service.

3. Understand that the products we use or consume are available because other water users had the water that enabled them to provide those products.

4. Appreciate the importance of a water source to a water user.

5. Relate our present quality of life to the availability of water.

Background

Water works for people in many ways. Some ways are more obvious than others. For example, water is used for growing crops and raising livestock, for drinking, for washing dishes, and for bathing. Some uses are not so obvious: manufacturing automobiles and textiles, shipping grain down our country's waterways, and building homes.

Use the following "did you know" examples to make your students aware of the large amount of water used in the production of goods that people use and enjoy.

Did you know that it takes:

* about 1800 gallons of water to produce the cotton in a pair of jeans and 400 gallons of water for the cotton in a shirt.

* 4,000 gallons of water to grow one bushel of corn.

* 11,000 gallons of water to grow one bushel of wheat.

* 135,000 gallons of water to grow one ton of alfalfa.

* four times more water to produce food and fiber than for all other uses of water combined.

* 1000 gallons of water to grow the wheat and make a two pound loaf of bread.

* 4000 gallons of water to produce a pound of beef, so it takes 1000 gallons for a quarter pound hamburger.

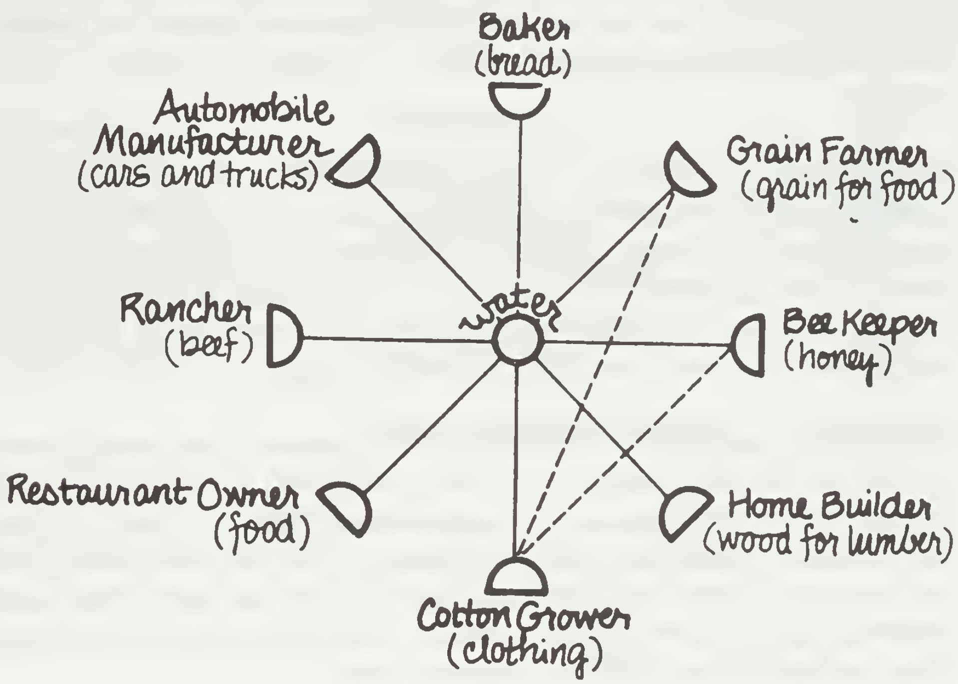
* 16.5 gallons of water to manufacture a 12-ounce can of soft drink.

* 32,000 gallons of water to manufacture one ton of finished steel (the amount of steel in a typical car).

Water is an important ingredient in most manufacturing processes. The availability of water is often one of the chief limiting factors when a new industry is looking for a place to establish its manufacturing plant. A city that does not have a good water supply has little chance of luring new industries.

Materials

Ball of string
Scissor
Marking pens
Poster paper for identification labels



Activity

1. Ask your students to clear an area in the center of your classroom. Leave one desk or chair in the middle of the cleared area and tape a sign to it that says "Water".

2. Ask your students to think of several different kinds of water users (a farmer, baker, a rancher). Have each student write what type of water user they are on a piece of poster paper and tape it to their body. You may want to write the different types of water uses on the blackboard.

3. One at a time, have each student tie a string from themselves to the water chair and then move back five to ten feet. The string represents the water user's need for water. Continue this process until all of your students are connected to the water chair.

4. Ask the person who started the activity to mention a few ways he or she uses water and what types of products or goods, if any, he or she grows or manufactures. An example would be: "I am a farmer. I use water to grow crops that are sold to mills. The mill grinds the grain into flour that is sold to bakeries that bake bread." Ask the other members of the circle to raise their hands if they use the products that a farmer produces. Connect another string from the water user (farmer) to the students who raised their hands. The teacher or teacher's aid should help connect the string to the students. Have all the members of the circle repeat the above process.

5. Your students will now be connected to one another by many strings. This is when you can explain that water plays an important role in our society and that most of the goods and services available to us today use water in the production process.

6. Water Quantity Extension - Explain to your students that when the water supply container lifts off the ground, this means the supply is being over extended. Asked your students to discuss options for reducing water consumption. What water users, if any, can reduce consumption? With a scissor in hand, ask which of the strings (waterlines) could be cut. What would be the result of this action? If appropriate, cut one or two lines to show the impact.

   Water Pollution Extension - Not only is it important to have enough water to meet the needs of water users, it is also important to protect the water from contamination. Explain to your students that the bottle of food coloring that you are holding represents a source of pollutant. Open the water supply container and place a drop of food coloring in the jug watching the water change color. The message will be clear on the importance of protecting surface and ground water from contamination as the dye taints the water.

Closure

End this activity by asking the student with the most strings attached to gently pull on them. The tugging effect that is felt by the person on the other end of the string represents that person's reliance on both water and the product.

ENERGIZING WATER

Objectives: Students will be able to:

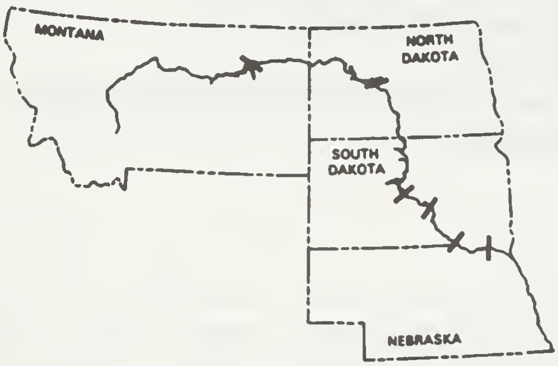
1. Understand the basic principles of how hydroelectric power plants work.

2. Understand the multiple purposes of a dam and reservoir.

Background

Fort Peck is one of Montana's many hydroelectric generating plants. Water from Fort Peck Lake fuels this plant. In addition to the hydroelectric plant at Fort Peck, there are five other hydroelectric plants on the Missouri River. The names of these plants, the associated dams, and the power generated are listed below:

Name of Dam	Reservoir	Generating Capacity (megawatts)
Fort Peck, Montana	Fort Peck Lake	185
Oahe, South Dakota	Lake Oahe	700
Big Bend, South Dakota	Lake Sharpe	468
Fort Randal, South Dakota	Lake Francis Case	320
Gavins Point, South Dakota-Nebraska border	Lewis and Clark Lake	100
Garrison, North Dakota	Lake Sakakawea	450
	Total Generating Capacity	2248



In addition to power generation, the reservoirs were built to help control floods, enhance downstream navigation, supply water for irrigation and municipal consumption, conserve fish and wildlife, and improve downstream water quality. Water-based recreation facilities make these reservoirs popular fishing, boating, and camping sites.

Background on Power Generation

There are seven fundamental components in a hydroelectric power plant: a reservoir, a dam, a pipe leading from the reservoir behind the dam down to the power plant, turbines, generators, transformers, and power lines to transmit the power from the plant to where it is used.

A turbine looks, and operates similar to, the propeller on a boat. The water comes down from the dam through the pipe and the force of the water turns the turbine blades, causing them to rotate as the water continues to flow downstream. The generators are connected to the rotating turbine and they, in turn, are rotated. This produces electricity through the use of magnetic fields. The electricity generated is then converted by the transformer to a higher voltage level and sent out from the plant.

Production of hydroelectric energy involves the conversion of the kinetic energy of flowing water, first to mechanical energy in a rotating turbine or wheel, and then to electrical energy in the generator.

The amount of energy that can be extracted from the water depends on the rate of flow (Q), the vertical distance it falls or head (H), and the plant efficiency (E). Therefore, the same electrical energy can be generated either with a high head and low flow, or a low head and high flow.

The relationship expressed mathematically is:

P = QHE divided by 11.8

where:

P = power plant capacity (kilowatts)
Q = rate of flow (cubic feet per second)
H = distance water falls (feet)
E = plant efficiency (0 E 1)

The division of 11.8 is due to the conversion of kinetic energy to electrical power. There is energy lost in the conversion process.

Materials

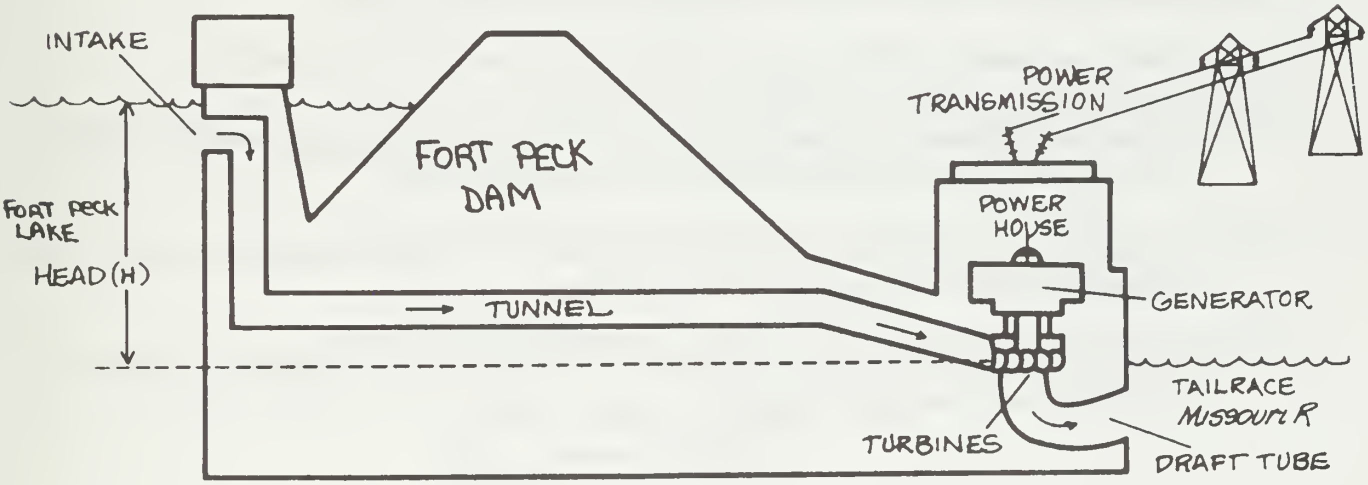
* Chalkboard
* Balloons

Introduction

Discuss the power water shows in nature. The erosion of the Badlands, the pounding waves at the beach, the roar of a waterfall can all be used to illustrate this point. Talk about how man has harnessed this power over the ages, i.e., water wheels used in grain mills and sawmills, and also to power machines in industry.

Introduce the basic forms of energy involved in hydroelectric power generation: kinetic, mechanical, and electrical. Demonstrate each one.

> Kinetic - Have two students stand in front of the class. Tell one to walk across the front of the room and the other to run to illustrate different levels of kinetic energy.
>
> Mechanical - Have another student pick up a heavy object in one hand and a light object in the other and use their experience to show it takes more mechanical energy to pick up the object with the greatest weight.
>
> Electrical - Lightning, static electricity in clothes, etc. You can use an inflated balloon, rub it against your clothing and illustrate how the charge build-up will make it stick to the wall.



Activity

Draw the schematic of a power plant on the board. (See drawing.) Label the head distance (the vertical distance the water falls.) Work through a sample problem on the board. If the head distance (H) is 100 feet, the water flow (Q) is 1000 cubic feet per second, and the plant efficiency (E) is 50%, what would be the power plant capacity?

$$P = \frac{QHE}{11.8} = \frac{(1000)(100)(.5)}{11.8} = \frac{50{,}000}{11.8} = 4237.29$$

Answer: 4237.29 kilowatts (kw)

What would the answer be in horsepower?

1 kw = 1.34 horsepower, so
(4237.29 kilowatts = 5677.97 horsepower)

Create additional word problems with the data provided.

Closure

Ask your students to discuss the importance of electricity to their family. They will most likely say that electricity is very important. Summarize the multi-purpose role that dams play. Take a poll of your students' attitudes on the most important role of a dam. List their responses on the blackboard and discuss. Point out that there is not one most important role.

Evaluation

Make up a simple true/false quiz. The following statements are all true:

* Water must have a vertical drop for a hydroelectric power plant to work.

* The turbine functions to convert kinetic energy into mechanical energy, and the generator serves to convert the mechanical energy into electrical energy.

* The electrical power generated must be converted to higher voltages in order to be transmitted away from the plant in overland lines.

* The higher the water level behind the dam, the higher the head distance, and therefore, the greater the power plant capacity.

"WATER: READ ALL ABOUT IT"

Objectives: Students will be able to:

1. Participate in the process of writing a newspaper.

2. Understand that water plays an important role in all aspects of life.

3. Better understand the concept of and benefits derived from cooperative efforts.

4. Develop writing and editing skills.

Materials:

Newspapers, tabloid-style paper (newspaper size), pens, pencils, marking pens, tape or glue, and scissors.

Instructions:

1. Circulate your town's or region's newspaper to your students for them to examine. Have the students write down on a piece of paper the different sections of the newspaper.

2. Teacher will discuss with students the parts of a newspaper and what information these parts contain.

3. Teacher will make a list on the blackboard of newspaper parts and their purposes.

4. Teacher will discuss with students how "reporting" differs from other types of writing.

5. Students will be assigned to one of the following jobs in newspaper work:

   Publisher: school and class
   Editor: teacher or students
   Reporters
   Artists
   Printer
   Photographers (optional)

6. Students will begin work on a class newspaper based on water education. The primary emphasis will be on water topics from your school district area and from around Montana. Various reporters will be asked to interview

local authorities on water control, water problems, water pollution, industrial uses of water, etc. Other reporters will create news stories for the various sections of the newspaper that appeal most to them.

These sections could include:

Front-page main stories
State, regional, and local news
Editorial
Letters to the Editor
Sports and Recreation (hunting, fishing, etc.)
Weather
Business/Economics
Agriculture
Cartoons

7. Students should be encouraged to write an article on a water topic that is of personal interest. The teacher (editor) will assist the students in selecting topics.

8. Deadline: This project will take five days to complete. Give your students three days to research a topic and prepare an article. They will need this time to prepare graphs, interview people, read reference materials, and to write the articles.

9. The articles will be given to the proofreaders who will proofread them and send them on to the editors who will select the most appropriate (at least one by each student in the class). The editors will forward them to the printers who will develop a finished copy of the newspaper.

Closure/Evaluation:

As a follow-up activity, the newspaper will be posted in the classroom. After students have had a chance to read the paper, it will be taken to the photocopying area, and students will be allowed to photocopy (purchase) a copy of the paper if they wish to have one. Additionally, the students will be asked to do the following:

1. be able to explain the parts of a newspaper,
2. explain how "newspaper reporting" differs from other writing, and
3. explain how their opinions of water have changed.

Extension:

Invite the publisher or editor of the local or county newspaper to speak to your class. The editor should discuss the role of the newspaper in relaying information to the public.

WHAT'S IN A NAME

Objectives: Students will:

1) research the origins of names of selected Montana waterways (rivers, streams, and lakes),

2) learn how waterways get their names, and

3) write short creative essays on the names of selected waterways.

Background

Montana has thousands of rivers, streams, and lakes that come in all shapes and sizes. Most of the waterways were created by the forces of nature. Thousands of natural lakes, ponds, and sloughs (wetlands) dot the state. Most of these bodies of water were created by the glaciers. The unglaciated land is well drained by rivers and streams and consequently has few natural lakes.

In more recent times, people have constructed hundreds of man-made reservoirs. These range in size from the massive Fort Peck Lake to small reservoirs like Hyalite Reservoir south of Bozeman. This activity will explore the origins of the names of Montana's waterways.

Waterways are important geographic landmarks. The pioneers and early explorers used the waterways in their travels. The waterways were given names so that people migrating to an area or through the region could have reference points to guide their travels. The Indians also gave the waterways names. Some of the Indian names include: Big Muddy (for the Missouri River), Medicine Lake (because the water was thought to have healing powers), and Flathead Lake (named after the Flathead Indian tribe).

In most instances, the name given to a river or lake provides some clue about the character of the waterway. Some bodies of water like Yellow Water Reservoir, Milk River, and Redwater River got their names from their unique coloring. Some waterways were given Indian names. For example, Sacagawea River is named after the Indian maiden who helped guide the Lewis and Clark expedition. Others are named after the waterway's dominant vegetation - Willow Creek, Poplar River, or Ash Creek. The names of Red Rock River and Yellowstone River originated from the rocks that dominate their shorelines. Names like Little Dry Creek and Alkali Lake were appropriately labeled because they tend to dry up during dry years. Natural disasters can bring about the naming of new lakes, such as Quake Lake, which was formed by the great earthquake of 1959. Gold Creek received its name because it was the site of the first gold discovery in Montana.

There are also a large number of lakes and streams that have more mysterious, imaginative, and provocative names. Examples are Deadman's Basin, Freezeout Lake, and Kicking Horse Reservoir. Unfortunately, the stories behind the names of most lakes and streams are not known. This is unfortunate because some of the names are truly unique to Montana and to Montana's rich, natural heritage.

Materials

Montana highway map and a Highway Department county map

Procedure

1. Have your students complete the worksheet on the origin of names. Each student will need a Montana highway map. Your students should look for names of rivers, streams, and lakes that relate to each category. (For example, the Red Rock River is a waterway that has a name that is also a color.) Review and discuss the names the students listed on the worksheet. Ask your students why they feel it is important for lakes and rivers to have names. Discuss the importance of landmarks to the early explorers.

2. Here is a writing exercise called the 'Landmark Game' which will help your students better understand the importance of waterways as landmarks and their use in traveling across a roadless land. Each student should have a Montana highway map. The instructions are as follows:

    > The object of the 'Landmark Game' is to have each student write a letter providing directions for one of their classmates to follow to get to some town in Montana. Students receiving a letter must determine the name of the town by the following directions. The only instructions that can be given are: compass directions (north, south, east, and west and combinations such as SW and NE, etc.), the names of rivers and tributary streams, the names of land formations (i.e., the Big Belts and the Bob Marshall Range), the names of historic sites (i.e., Fort Benton and Fort Peck), and the distance between given landmarks using the mileage scale found on the Montana highway map.
    >
    > The student receiving the letter and directions is traveling by canoe so he or she must stay on the rivers most of the time. This means the directions must be written in such a manner as to keep the travelers on a waterway as much of the trip as possible. Make sure all of the destination towns are located on rivers. The directions should begin at a point on the Montana map where the river either enters or exits the state. For example, if one of your students selects the city of Billings in southeast Montana, he or she should give the directions beginning at 1) Fort Benton (paddle upstream) or 2) Yellowstone Park (paddle downstream).

The letter cannot include a map; however, the student who receives the letter can try to create a map from the instructions. The game is over when the student who received the letter locates the town. If the student cannot locate the town, another more descriptive letter must be written. The students should then reverse roles. This will give both sets of students the opportunity to write a letter and to follow directions. Have your students turn in their letters for grading.

3. Your students will then write their own original story about the name of one of Montana's waterways. The story should be imaginative and creative. For example, if one of your students selects Dead Man's Basin Reservoir, he or she could write a mystery story about a missing man and how he might have met his fate. (Note: The Highway Department's county road maps are excellent sources of the names of small streams and lakes.)

WHAT'S IN A NAME - Student Worksheet

Category	Names of lakes, rivers, and streams
Shape	______________________________
Tree	______________________________
Geologic features/formations	______________________________
Quality of the water	______________________________
Indian name	______________________________
Wild animal	______________________________
Domestic animal	______________________________
Person's name	______________________________
Explorer's name	______________________________
Woman's name	______________________________
Tragedy	______________________________
Natural disaster	______________________________
Types of grass or flower	______________________________
Color	______________________________
Town	______________________________
Direction	______________________________
Type of food/beverage	______________________________
Action or event	______________________________
Precious metal or gem	______________________________
Fort/military reference	______________________________
Day of the week	______________________________

EASY STREET

Objectives: Students will be able to:

1. compare and contrast present day household uses of water with past household water uses,

2. better understand how technological improvements in water handling and distribution influence the quality of life, and

3. participate in an 1890 Water Day Project.

Background

Many changes have occurred over the past 100 years in the ways people use water in and around the home. Standard household equipment of 100 years ago, such as the washboard, the hand pump, the burlap-wrapped water jug, the icebox, the water bucket, and the stomper (hand agitator), have been retired to the shelves of antique stores. These items once served a valuable purpose in rural and urban homes. This activity will demonstrate that modern-day people live on "Easy Street" when it comes to household water use.

\ our students will be amazed at the amount of work involved in performing the common tasks of washing clothes, bathing, or washing dishes. Although taken for granted today, most uses of water (like those listed above) required a great deal of time and energy to perform.

Quality of life improvements have always been welcomed. The local hardware store kept most families aware of new innovations arriving on the market. As family finances permitted, people purchased and took advantage of newfangled household equipment, such as the hand-cranked clothes washers. The new gadget would probably only be purchased, however, if it ranked above the farm or ranch equipment on Pa's wish list.

The delivery of electricity to rural areas had a profound impact on the quality of life of most rural Montanans. Here are a few thoughts describing household chores prior to the availability of electricity:

> "We cooked on a coal range with a reservoir on the side to heat water. Water was carried in pails and when the windmill wasn't turning, we pumped it by using the hand pump. Washing was done by heating water on the coal range, rubbing clothes on the washboard; clothes were rinsed by stomping them with a clothes stomper and were hung on the line to dry."

> "Sewer systems consisted of a pile in back of each house, or a stream channel through town. During warm days...the smell was so bad you could see and taste the air."

"Dad tried to dig a well but gave up at about ten feet after hitting solid rock. Then he brought in a well digger. The cable tools were operated by a stationary engine mounted on running gear and pulled by a team of horses. Good water was hit at forty feet and a hand pump brought it to the surface."

The articles on the last page of this activity were reprinted, with permission, from Marian Crammer's book entitled "Lantern Glow." These stories accurately depict a time when people respected the importance of water.

The following discussion highlights some of the differences between household uses of water in 1890 and uses today.

Categories

1. Running Water

Today - Water is only as far away as the tap. All of Montana's towns and all but a handful of the rural people have running water. Most urban residents and a growing number of rural people have water delivered directly to their homes, businesses, and farms and ranches via municipal or rural water distribution systems. If you are interested in learning more about rural water systems, refer to the activity titled "Rural Water" on page __. Both types of water systems function in the same manner. Water is pumped from a source, treated, and delivered to the water users through underground pipelines called water mains. If a person living in rural Montana doesn't get his or her water from one of the above systems, he or she usually gets water from a well.

It's a fact that using water in 1990 is easy. All a person has to do is turn on the faucet. There is little or no work involved. Normally, when a home is hooked up to a municipal or rural water system, the occupants can use as much water as they want provided they are ready and willing to pay the bill for the amount used. One exception to this luxury of unlimited water use may occur during times of drought when supplies are low and demand is high. Water system operators are sometimes forced to ask their water users to conserve water.

1890 - Running water was only available in a few Montana cities. Most small towns and farms of Montana did not have running water until the late 1930's and the 1940's when electricity gradually became available across the state. There is an interesting and not so apparent relationship between the advent of rural electricity and running water. Prior to electricity, running water on the farm literally meant "running" with a bucket of water. Rural electricity drastically changed the quality of life, particularly as it is related to household water use. The windmill, driven by the wind, and the hand pump, operated by human power, were replaced by electric motors. Electricity powered dishwashers, refrigerators, clothes washing machines, clothes dryers, and water heaters, saving people both time and energy.

The bottom line was that hauling water was a lot of work. Water was usually hand-pumped or bailed out of a well or cistern and hauled in buckets to the point of use. (Note: A five gallon bucket of water weighs about 45 pounds.) The well was often located near the barn and the livestock to reduce the hauling distance. Close proximity to the livestock had advantages and disadvantages. The main advantage was in the time and energy saved while hauling water to the livestock. The main disadvantage was the potential for contamination of the well from animal wastes. Water quality tests have revealed that a high percentage of the old, poorly located and constructed wells are contaminated.

Years ago, most households had a water bucket specifically designated for drinking water. When a person was thirsty, he or she would get a dipper (the "community cup") full of water from the water bucket and take a drink. When the bucket was empty, someone had to haul another bucket of water to the house. To keep the water cool during the warm months, the bucket was usually located in the unheated entry way or next to the sink in the kitchen.

Another method of harvesting, storing, and using water was the cistern. The cistern was a tank or vault usually constructed underground to collect and store water which was either hauled in and/or channelled off the roof through gutters and a downspout into the cistern. The water was then pumped out of the cistern when needed. The cistern was notorious for collecting leaves, twigs, dead birds, and small animals (i.e., mice). While cisterns were periodically cleaned and sanitized, the quality of the water stored in the cistern was often poor, but it was soft. The water from the cistern was most often used for bathing and clothes washing. Most homes got their drinking water from a well and stored it in a water bucket.

2. Hot Water

Today - Most homes are equipped with either electric or gas water heaters. All that is required to get hot water is to turn on the faucet and regulate the water to the desired temperature. Water heaters store around 40 gallons of water. Running out of hot water is usually not a problem.

1890 - Water was pumped from the well or cistern, carried to the house, and then heated in a kettle on the stove or in the stove's water reservoir. The stove's water reservoir would store 3 to 5 gallons of water. Water remained hot as long as there was a fire burning in the stove. Fuel used to heat the water also had to be hauled. The fuel type varied from wood to dried cattle wastes called "cow pies" or better known during the buffalo era as "buffalo chips".

3. Bathing

Today - All a person has to do is turn on the water faucet, regulate the water temperature to his or her liking, and shower or bathe for as long as he or she wishes. When bathing

is completed, the "used" water is drained through the home's plumbing system either to a central sewage collection system or to a septic system.

1890 - A person would have to haul water in from the well, heat it on the stove, then haul the hot water to a wash tub. This might take several trips to the well and a half hour or longer to heat the water hot enough for a bath. Water temperature was regulated by adding hot or cold water. Members of most families, especially the larger families, did not spend much time in the tub. A long, leisurely bath meant more water hauling and time at the stove. There is little doubt that a bath was truly a luxury. Once the bath was over, the dirty/soapy water was hauled outside or saved to wash the floor and then thrown out. After washing the floor, some families further conserved by using the water on the garden.

Some families melted snow and collected the water for a source of soft water. While this required an extra effort, it seemed that washing with snowmelt water was a special treat. People also collected rainwater for bathing and washing clothes. Rainwater was collected and stored in a rain barrel outside of the house or in a cistern.

4. Dish Washing

Today - Many homes are equipped with automatic dishwashers. Dirty dishes are loaded into the dishwasher and the machine does the work - washing, rinsing, and drying. Families who do not have a dishwasher wash dishes the old-fashioned way. Running hot and cold water, waste disposal systems, and plumbing connected to sewer systems have helped to save time spent on this daily chore.

1890 - Water was collected, heated, and placed in two containers - one for washing and the other for rinsing. Sinks were usually a single basin with a drain that often went right into a bucket. The used water was carried outside for disposal.

Some families gave the wash water, plus other meal wastes, to the hogs or chickens. This mixture of wastewater and scraps was called "slop". Most, if not all, homes had a slop bucket. The disposal of this wastewater was a particular nuisance in town. When slop was disposed of outside, it was usually eaten by neighborhood dogs, cats, birds, and rodents. The slop was also dumped down the privy or worked into the garden as fertilizer. Solid wastes such as paper, cans, and glass containers were burned in a pit or trash can. Some towns employed a person called the Drayman who would collect and haul away the winter's accumulation of solid wastes and ashes to a dump in the early spring. This uncontrolled, and obviously unsanitary, method of disposing of wastes was the impetus behind modern central wastewater collection systems and landfills. People sometimes complain about how haphazardly society handles its wastes today; however, in comparison with past disposal practices, our sanitary conditions are vastly improved. Unfortunately, many of today's pollution problems are results of poor disposal activities.

5. **Clothes Washing**

Today - Clothes are placed in an automatic washing machine and the machine washes the clothes. The clothes are then placed in a gas or electric dryer to dry.

1890 - Water was pumped, hauled, heated, and poured in one or more wash tubs. One tub was used for washing clothes and the other for rinsing. Some of the standard wash day equipment included a bucket, wash tubs, a washboard to scrub soiled clothes, a stomper (clothes agitator), a forked wash stick to retrieve clothes from the hot, soapy water, a wringer to wring out excess water, and a clothesline for drying the clothes. Clothes washing was a big job and required a lot of time and energy.

Water was heated outside during the warmer months to avoid heating up the kitchen area. Many homes had a laundry stove which was usually a small wood, oil, or Kerosene burner, used to heat water for clothes washing.

6. **Bathroom Facilities**

Today - Homes are equipped with toilets that flush waste into a septic system or into a municipal sewer system. The user simply flushes the toilet and the waste is gone. In the case of cities, the wastewater is collected by an underground network of sewer pipes and sent to a plant where it is treated and eventually returned to the environment. When constructed, operated, and maintained properly, this is an environmentally sound system. The cost of proper waste disposal is a small price to pay for a much cleaner and healthier environment.

1890 - People used outdoor privies (outhouses) to go to the bathroom. The outhouse was used year round even when the temperature was 100 degrees above zero and the privy emitted a powerful stench, or when it was 40 degrees below zero and the privy's wood seat was almost too cold to bear. Some families used indoor "Chamber Pots" or "Commodes" for evening use or during bad weather.

The outhouse was placed over a pit which was dug by hand. The wooden outhouses were built and sold as one-, two-, or three-seaters. Toilet paper as we know it today did not exist. People could order toilet paper from the Sears Catalog, but most could not afford this luxury. Some families used the soft paper wrapped around fruit. Other forms of toilet paper included newspapers, magazines, and catalogs. People made due with whatever paper was available.

The outhouse required no water and very little maintenance and was retired or relocated when waste filled the pit. Most of the old and abandoned outhouses have been destroyed and the pits buried. Many old outhouses met their fate at the hands of Halloween pranksters. It was a Halloween tradition in some areas to tip over outhouses.

Although the outhouse served a valuable purpose, it was a rather unsanitary method to dispose of waste. This was especially true in town where concentrations of homes and

businesses relied on water from shallow wells. If a well and an outhouse were located too close together, there was a chance the well could be contaminated. This is another of the reasons most towns constructed central sewage collections systems.

The early central sewage systems did a good job of collecting sewage; however, they often did not treat the wastewater before it was dumped into streams, rivers, or lakes. In later years, lagoons and wastewater treatment plants were added to further treat the wastewater.

7. **Refrigeration**

Today - Most homes have refrigerators and freezers. Many refrigerators automatically freeze and dispense ice as well as dispense chilled water.

1890 - Ice harvesting was done in the late fall and winter to gather ice for use during the following spring, summer, and early fall. Ice was cut from rivers, streams, and lakes and hauled to the icehouse where it was stored. Ice blocks were insulated by packing them in sawdust or straw. Ice companies sold the ice blocks to homes and businesses such as grocery stores for their coolers and to railroads for refrigeration cars. Some families constructed their own icehouses. Ice was sold by the pound or by the block. Blocks of ice were delivered to customers in an ice wagon or truck. The iceman knew when his customers wanted ice because an ice card was displayed in one of the home's windows. The customer paid for the ice with cash or with ice coupons purchased from the ice company. The iceman carried blocks of ice with ice tongs. The iceman wore a leather apron with pockets to collect the dripping water and chips. The ice blocks were stored in homes in the icebox or ice chest. The icebox served as a refrigerator. Small pieces of ice were chipped off the large block as needed by using an ice pick. Small pieces of ice were chipped off the blocks and used in drinks like ice cubes. Ice harvesting was a lucrative business and most Montana cities had an ice company.

Food could also be kept cool by placing it in a bucket that was lowered into the well to take advantage of the cooler environment.

8. **Cooling Water for Drinking**

Today - Tap water is naturally cold. People use insulated coolers to keep water cool for outside use during warm weather.

1890 - It was a difficult task keeping water cool for extended periods of time outdoors. Pioneers relied on several simple methods to cool water.

One of the simplest methods of cooling water involved placing a jug of water in a stream, root cellar, or in a stock tank. The idea was to capitalize on the cooler temperature of water in the stream or tank or the coolness of the air in the root cellar. The temperature of water pumped from the ground is naturally cool (45-55 degrees Fahrenheit). On hot, windy days, when the livestock consumed a lot of water, the windmill pumped large

quantities of cool well water into the tank.

Some families cooled water by wrapping a gallon jug with burlap and immersing the jug in water. As water evaporated from the wet burlap, the water in the jug was cooled. This was a short-term solution, however. When the burlap dried, water inside the jug would quickly warm to air temperature again.

Water was also cooled in water bags. Water bags were constructed of canvas and sold commercially. When a water bag was filled with water and taken outside on a hot day, water droplets would begin to form (sweating) on the bag's outer surface. This process is similar to how people perspire on a hot day. Perspiration causes us to feel cool as moisture evaporates from our skin. The water bag was often draped over an automobile's mirror or grill or over the saddle horn of a saddle. As the horse or vehicle began to move, air should move over the moist outer surface of the water bag aiding in the cooling of the water inside the bag.

9. Watering the Lawn

Today - Thick, green, well groomed lawns are somewhat of a status symbol. Homes are equipped with outdoor spigots making water readily available for watering the lawn. Some homes are even equipped with underground sprinkler systems, which can be programed to sprinkle water on the lawn at pre-determined times of the day.

It is important to remember that the water used for watering the lawn comes from the same source as the water used for household purposes. In situations where water is supplied by a utility, a fee is paid on a monthly, quarterly, or yearly basis. There is normally no limit on the amount of water that can be used for watering lawns, except during extreme warm or dry spells when the utility cannot process or treat enough water to keep up with the demand.

1890 - Lawns were not watered in 1889. There was no easy method of distributing the water on the grass. Other tasks connected with survival and earning a living were of much higher priority.

10. Watering the Garden

Today - Same as watering the lawn.

1890 - Garden placement was very important. Placement of the garden was carefully considered so the gardener shouldn't have to spend most of the summer hauling water. The closer the source of water, the shorter the walk to the garden.

Like today, past gardeners relied heavily on rainfall. When rains came infrequently, water hauling would begin. This was done conservatively, watering each plant individually. Less water wasted meant fewer trips to the water source.

11. **Swimming**

Today - Community swimming pools are common in Montana towns. Some families have their own personal swimming pools. Indoor pools are also available for year round swimming. Pools are supplied water by municipal water systems and most are heated.

1890 - When time permitted, swimming took place in rivers and lakes.

Procedure

This activity has two components: 1) classroom discussions and 2) the 1889 Water Projects. In an attempt to bring reality into the lesson, instructors are encouraged to incorporate the 1890 Water Projects into the discussion sessions.

1. As an introduction to this activity, have your students read the "Cool Clear Water" and "The Bath" stories. What do your students think about hauling water in a bucket, bathing once or twice a week, or bathing in the same water used by other family members? Ask your students if they would bathe once or twice a day, as is common today, if they had to pump, haul, and heat the water? If there is a mixed response (there should be), lead your students through the 1890 Water Project on water hauling.

2. Have your students create a list of the ways their families use water in and around the house. Explain that people use water for many of the same purposes (i.e., bathing and cooking) as people did 100 years ago. The big difference is found in the ease of using water today and in the quantities of water used. Students' lists should include uses such as bathing, clothes washing, flushing the toilet, dish washing and, if you live in a rural area, watering the livestock. It might be helpful to list rooms in a house such as the bathroom, laundry room, and kitchen, and then list the ways people use water in each room.

3. How did running water improve the quality of life? (People save a great deal of time and energy in performing household chores.) What makes these savings possible? (People are willing to pay money for products and/or services which make life easier, safer, or more productive.) The need to improve one's living conditions is the basic premise behind most, if not all, technological advances.

   After you have reviewed the life-style improvements made possible by running water, discuss some other technological improvements which have enhanced living conditions. For example, prior to the invention of the automobile, people traveled by steam-powered vehicles or by horse and buggy. The automobile made for much easier and more comfortable transportation. Similar changes have occurred in other areas (i.e., communications - telephone, television, computers). Water use is no exception. Ask your students to think of some other areas where noticeable changes have taken place (i.e., central collection sewage treatment systems and community and rural water systems). In each case, try to uncover what effect the change has made on society.

1890 WATER PROJECTS

The following projects are designed to be incorporated into the discussion sessions as individual projects or as a complete unit.

Project One - "The Community Cup"

The water bucket was normally located in the entry way of the house to provide the thirsty person with a quick drink. A ladle (dipper) was often hung over the edge of the bucket. In later years, schools made use of a crock equipped with a spigot to dispense water. A paper cup dispenser was located next to the crock.

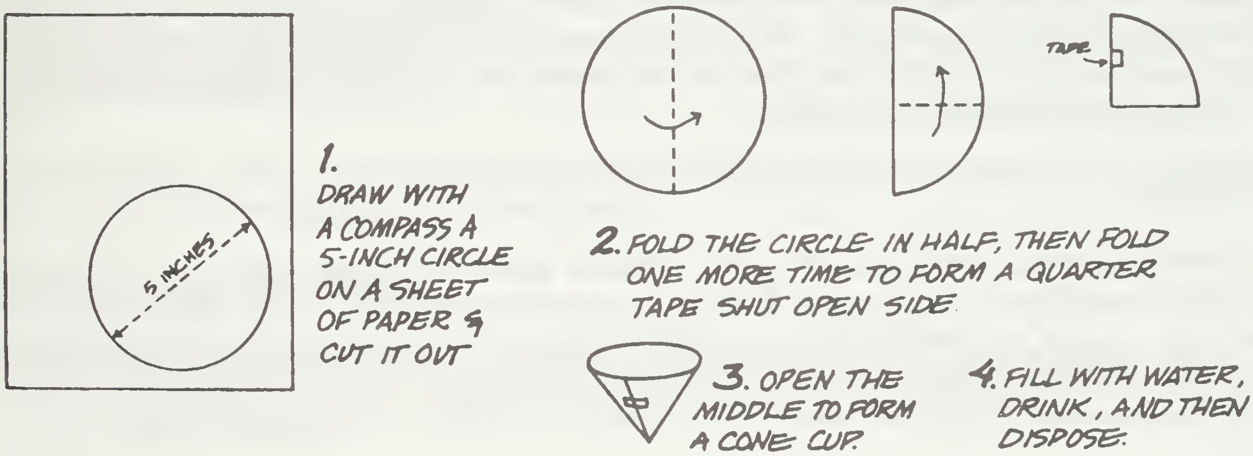
Procedure

Have two students carry an empty bucket to the kitchen, fill it with water, and carry it back to the room where it should be placed near the teacher's desk. Make sure the bucket has a lid. Hang a ladle on the bucket. This will be your students' only supply of water for the day or for the week. This means no drinking from the water fountain. (SEE NOTE BELOW)

Each student must have a glass (8 ounces for his or her personal use. Each student can drink up to eight glasses of water per day. (This is the recommended amount of water a person should drink per day.) Each day, every student should be given eight drink tokens which can be exchanged for eight glasses of water. When the pail is empty, have a new pair of volunteers haul in another bucket of water.

NOTE: **Do not allow your allow your students to drink directly from the ladle or the bucket.** Explain that many disease-causing organisms live in and can be spread by water. Public health specialists call diseases spread in such a manner "waterborne diseases".

Have your students make their own drinking cup as shown below.



Project Two - Hauling Water

The average American family (3.2 people) uses 200 gallons of water per day. This includes all uses of water (i.e., bathing, flushing the toilet, and washing clothes). Ask your students if they would use 200 gallons of water a day if they had to haul it. Have your students guess how much 1 gallon of water weighs. (8.34 pounds) How much would 200 gallons of water weigh? (1668 pounds)

Procedure

Have your students haul 200 gallons of water. Use several 1-gallon ice cream buckets to haul the water. Haul the water from an outdoor spigot to a tree or to several trees. Your students will be amazed at the amount of time and energy it takes to haul the water. Would they be as apt to waste water if they had to haul it for household use every day?

Project Three - Water Bottle/Water Bag

Wrap a 1-gallon jug with burlap cloth. Next, fill the jug and soak the burlap with water. Wet the burlap-covered jug and a jug without a cover next to one another on a table or counter. Compare the temperature of the water in the burlap-covered jug to the water in the plain jug. What is the difference in temperatures between the plain jug and the wrapped jug after 10 minutes? 20 minutes? 30 minutes? When the burlap wrapper is dry, soak it again. To explain what happens, have each student dunk his or her hand in the bucket of water. When they remove their hand from the water, the air flowing over your students' hands will create a cool feeling.

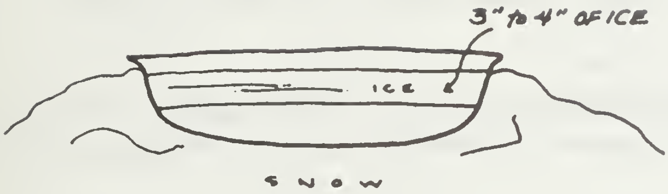
If a water bag is available, show your class how it works. Compare the water temperatures of the water in the water bag and the water in the jug wrapped in burlap. Which is the most effective? Explain how the water bag keeps water cool. (evaporation)

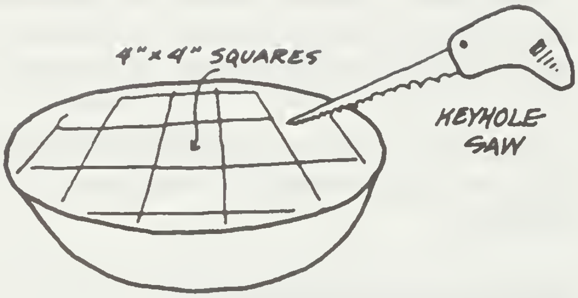
Project Four - Ice Harvesting

Ideally, this project should take place outside on a frozen pond, lake, or stream. Your students, with a great deal of supervision, would watch some adult volunteers harvest ice like the ice companies once did. It might be difficult to find people familiar with ice harvesting or that have the equipment necessary to harvest ice.

Procedure

A safer alternative would be to fill a large washtub about 3/4 full of water. Let the tub set outside overnight or long enough to form a 3- to 4-inch layer of ice. Cut or chip a hole in the ice large enough to allow the blade of a saw through it. (A keyhole saw is recommended.) Proceed to cut several small (4- x 4-inch) blocks of ice from the tub as shown below. If ice tongs are available, have your students use the tongs to remove and carry an ice block.





Project Five - Ice House Construction

There was more to ice harvesting than just cutting ice. It also involved the construction of buildings called icehouses. Wood was the most common material used to construct icehouses. Ice blocks were stacked with sawdust or straw layered between tiers of blocks. This configuration insulated the blocks and allowed them to be separated.

Procedure

This project will demonstrate the importance of ice harvesting, and even more importantly, the ability to store the harvested ice over long periods of time. It will also show the insulating qualities of straw, sawdust, and soil. The goal of this project is to store enough ice to make ice cream in Project Six as described below. Fill eight 1-gallon plastic milk containers with water and place them outside or in a freezer. Use four of the containers for this experiment. The other four will be used later for making ice cream.

Set up the following experiment:

Container #1 - Control (no insulation)
Container #2 - Insulated with sawdust
Container #3 - Insulated with straw
Container #4 - Insulated with soil

Which insulating material provided the best results: What might be the consequences of running out of ice early in the year? (i.e., spoiled food)

Project Six - Ice Cream Making

Ice was used in many ways. It kept food cold in the icebox and it was used in drinks. One of its more enjoyable uses was for making ice cream. Use some of the ice from the ice harvesting project to make ice cream.

Procedure

Select one of your favorite homemade ice cream recipes. To be consistent with the times, you should locate a hand-cranked ice cream maker. Do not use an electric ice cream maker. Give each student a chance to turn the handle on the ice cream maker. Use the ice from the ice harvesting project to make the ice cream.

As you and your class enjoy the ice cream, discuss the importance of ice harvesting. Why was ice harvesting eventually eliminated? (The advent of electricity to power refrigerators and freezers.)

<u>Project Seven - Soap Making</u>

Water has been called the universal solvent and is used in virtually all manufacturing processes. Water is used for cooling, for preparing food, and for cleaning.

Montana pioneers lived a frugal existence. They were self-sufficient and made good use of their resources. Soap making is one example of the pioneers' resourcefulness. Although commercial soap was available in some parts of the country, its availability in the newly settled areas was limited. As a result, most families made their own soap. This project will show your students how to make soap. You should stress the importance of water in the soap making process as well as the fact that the pioneers did not waste many things.

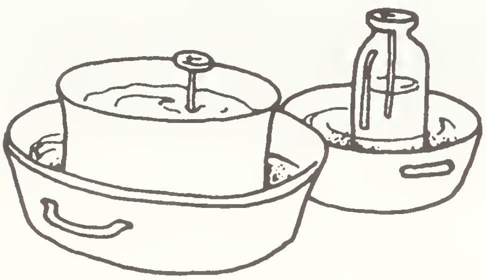
All soap is made by the saponification (chemical combination) of lye, water, and fat. Soaps will differ, however, depending on the kind of fat, the kind of lye, and the amounts of each used. There are two types of lye: the commercial lye (sodium hydroxide) which will make a hard soap, and lye made from potash which makes a soft soap. Commercial lye will be used in this demonstration.

Procedure

A. Batch (36) Bars of Soap

To make a standard batch of soap you will need: 1 can (13 oz.) commercial lye, 2 1/2 pints of water, and 6 pounds of fat.

After all the ingredients have been mixed, the liquid can be poured into one large pan and cut into bars after the solution has hardened. This recipe will yield 9 pounds of soap, enough for 36 bars of soap.

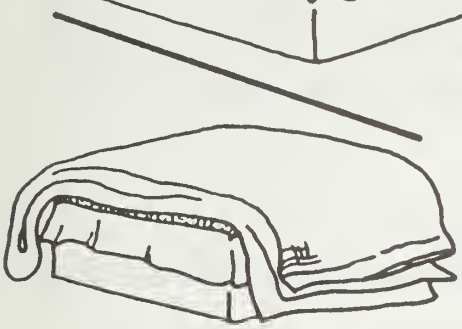


1. Slowly add the lye to the water to make the lye solution. Bring both the fat and lye solution to a temperature between 95 and 98 degrees Fahrenheit by placing them in pans of hot or cold water, depending on whether they need to be warmed or cooled.

2. To make sure the mixture is thoroughly combined, stir the fat before the lye is added. Pour in the lye solution in a steady stream, continuing to stir with an even circular motion.

3. The mixture will turn opaque and brownish, then lighten. The soap is ready when the surface can support a drop of the mixture for a moment. The consistency will be like that of sour cream.

4. Add colors, scent, or special ingredients. (Adding them earlier might interfere with saponification.) Pour the liquid into a mold and place in a warm location.



5. Cover the mold with cardboard, styrofoam, or blankets. The soap should be removed from the mold after 24 hours, then left uncovered in open air for two to four weeks.

B. Single Bar of Soap

If you want to experiment with a variety of colors, scents, and ingredients, it might be easier to make a single bar of soap rather than a large batch. You will need: 1/2 cup cold soft water, 2 heaping tablespoons commercial lye, and 1 cup melted beef tallow. (Follow the previous steps.)

C. Special Soaps

Floating soap - Gently whip the warm soap solutions with an egg beater just before pouring into molds. As the soap hardens, air bubbles will be trapped, causing the soap to float.

Cold cream soap - Thoroughly mix 2 ounces of commercial cold cream into soap solution just before pouring into molds.

Milk and honey soap (nourishing for the skin) - Thoroughly mix 1 ounce each of powdered milk and honey into the soap solution, then pour the solution into molds.

Scented soap - To a standard batch add 6 teaspoons of oil of bergamot, oil of sassafras or oil of cinnamon. Do not use commercial perfume; the alcohol will interfere with saponification.

Colored soaps - Candle dyes, natural dyes, and spices such as tumeric (food coloring does not work well) are added to the soap mixture or swirled into the mixture to "marbleize" the soap.

CREDIT: This information was obtained from Back to Basics, How to Learn and Enjoy Traditional American Skills, The Reader's Digest Association, Inc. 1981.

CAUTION: Soap and lye making are hazardous processes and should not be attempted without adult approval and supervision. Lye is a strong alkaline and can cause severe burns and serious injury.

Project Eight - Clothes Washing

There is little doubt that clothes washing was a time-consuming and laborious task. The process from start to finish involved: pumping and hauling water to the house, heating the water on a stove or in the stove's water tank, soaking and scrubbing the clothes on a washboard, retrieving the clothes out of the hot water with a stick (helping avoid sore fingers from the lye soap), rinsing, wringing out the water, and hanging the clothes out to dry. If this doesn't sound like a lot of work, try it sometime!

Procedure

Take one of the bars of soap and lead your class through the above process. If possible locate a washboard and tub to use when washing the clothes.

Project Nine - Water Conservation

Rainwater was collected in barrels. Place a 50-gallon garbage can beneath one of your school's downspouts. How long does it take to fill the can? Explain to your students how the cistern worked. It is obvious that a lot of water could be collected in a short time based on this experiment. Use the water in the garbage can to water your school's indoor plants.

Extension

1. Have your students interview their parents or grandparents about their past experiences with water. How have things changed? Have each student share the results of his or her interview with the other students.

COOL CLEAR WATER

Kerwhump-squeak, kerwhump-squeak. The cold water gushed from the pump. Was any drink ever as sweet as that you caught in an improvised hand-cup dipper and sucked up noisily?

Towering above the well was the windmill, sentinel of the prairie. Kicked into gear she whipped her AEROMOTOR or DEMPSTER tail away from the wind and pushed her wheel to catch the breeze. With a clank of gears the pump-stick began its up and down rhythm lifting cool water from the depths of earth, sending it splashing into the wooden stock-tank or waiting buckets.

It took very little wind to operate the mill. Ten to fifteen miles an hour would keep things going nicely.

The well was the hub of the farm. If possible the barn was located nearby. This was best for labor if not hygenic reasons. All livestock had a mighty thirst.

Children of the bygone era were, as now, loved for themselves but they filled a real need in the family unit. A child was measured, not only on the kitchen door where heights were carefully charted, but in the chores they were able to accomplish. A child could take pride in and know he was really growing up and amounting to something when he could help with the watering.

It began with a small bucket dipped full from the tank and lugged drippingly beside Dad who swung along with two five-gallon pails hanging light as feathers from his powerful fingers. Gradually you progressed to a twelve-quart galvanized pail that only had to be set down a couple of times as you watered the chickens.

That nice pail-full of water offered many youngsters their first practical lesson in physics. How fast must you windmill your arm, swinging the pail in a complete circle to prevent any water from spilling? No one mentioned centrifugal force; it was called "Spin the Pail".

You knew you had arrived the day Dad said, "Use the five-gallon pail beside the barn and water the pigs, I'll feed the calves."

It was a feeling of sheer power to stand by the fence, alone, pouring water into the hog trough as the squealing porkers fought noisily for a drink. The livestock, your family needed you!

The importance wore a bit thin as you made possibly ten trips. It was an incentive to keep trying to haul two pails at one time and cut the trips to five.

If the well and water tank were in the best possible position it might be possible to arrange fences so that at least two yards had access to it.

The water tank, because of its importance and danger, had an unofficial set of rules for children. For toddlers..."Stay away from the tank. You may fall in and drown."

For middle sized children..."Yes, you may sail stick boats on it but take them out when you are done and DON'T stir up the water. The horses will be in from the field at noon and need a good, fresh drink."

If by chance a few days of calm descended on the farm the hand pump would be pressed into service. Farm boys with an inclination for arithmetic could tell how many strokes it took to fill the tank.

Farm children were and are notorious dreamers of big dreams. Pumping water was a chore that required almost no concentration and visions of wonder flashed through active minds as they pumped away. Not one of the most accomplished, wildest dreamers envisioned a farm where water fountains supplied every pen and barn with an automatic supply of water, warmed and kept from freezing in cold weather; center-pivot irrigation units watering a quarter-section of land; or rural water systems with mains crossing the countryside bringing water to every farm.

If such notions had been proposed to a B.E. (Before Electricity) farm kid he would surely have laughed and answered..."Ya, come with me; I'll race you to the foot of the rainbow."

THE BATH

Ma took down the wash-boiler from the back-porch wall about three o'clock on Saturday afternoon and summoned her chief water-hauler, a boy about ten years old. He must fetch four pails of water for the boiler.

Though washday was past or coming whichever way you looked at it, this was Saturday - the night of the bath.

Ma and the girls would start things off with a head-wash every second week. Since their hair was long it was nice to do that in the afternoon as it would be completely dry by bedtime.

After supper the boiler steamed away on the stove. In winter the steam that collected on the windowpane quickly froze to thick, white frost but near the stove it was cozy.

Some families had tin bath tubs you could soak in. Some used the round rinse-tub from washday in which you stood and scrubbed; some used a wash basin. It was sort of a matter of tradition and using what you had.

The kitchen was hot with the stove really fired up. Ma brought out a big hooked rug and put it right in front of the open oven door. The turns usually went from the youngest to the oldest ending with Pa. Sometimes a boy or girl of courting age might have Saturday night plans and they could be worked in the early part of the schedule. During summer when the whole family went to town on Saturday night the bath hour was moved up so the baths came before town.

In winter Ma laid out neat piles of clean underwear and night clothes for each member of the family. With a pail of cold water at hand to blend with the hot water it was bath time.

Ma presided over scrubbing the small children until they were considered old enough to manage themselves and then they could bathe alone and be checked afterwards.

Privacy was honored. No one interfered as one by one the family members took their turn enjoying the nice hot water. It usually wasn't emptied between bathers, but more water could be added to keep it nice and warm. Homemade soap was used for scrubbing, but sometimes there was a bar of town-soap with its good smell.

There would be at least three bath towels for family use. These would be nice, soft, terry-cloth, not the hard huck toweling used for everyday. As one towel got wet it could be draped over the oven door to dry and later used again. Ma had likely cut and hemmed the wash rag from a bath towel gone thin in the middle.

There might be a bottle of lotion set on the table to smooth on elbows and rough heels.

Pa, the last one in the bath, took care of emptying the water into slop pails. He would wipe out the tub and hang it on the back-porch wall by the boiler.

Ma would come in quietly wearing her night clothes with her hair braided into one big braid down her back. She picked up the piles of discarded clothes for her washbox and tidied up the kitchen for tomorrow was Sunday.

Sunday could come. Her family was all clean for another week.

BUCKET BRIGADE

Objectives: Students will:

1) better understand the role that municipal water distribution systems play in a community's firefighting capacity, and

2) relate the technological advances in water distribution systems to improved public safety.

Background

Fire has plagued prairie towns frequently throughout the years causing enormous economic and personal losses. No town in Montana has been able to avoid the hardships that accompany a fire. Before Montana became a state, Billings, Miles City, and Livingston, communities which were built largely out of logs and wood, experienced major fires. Blackfoot City had a blaze in 1869 that destroyed most of the camp and it was never rebuilt. Helena survived three disastrous blazes between 1869 and 1874. After each, residents rebuilt, erecting a few more "fireproofs" (buildings constructed of brick or stone).

One of the earliest organized methods of fighting fires in a community involved a chain of bucket-wielding people known as a "bucket brigade." The dreaded sound of the fire alarm resulted in much chaos and calamity and caused many communities to go to extraordinary lengths to dowse fires.

Fighting fires has always been a difficult and dangerous task. Even with today's sophisticated firefighting equipment, fire continues to pose a serious threat to public safety.

Building a municipal water system was a high priority for Montana communities. The public demanded adequate fire protection and, in most instances, received it. Residents were willing to pay the price for modern firefighting equipment. Many small towns and rural areas formed volunteer fire departments, saving money, pooling resources, and creating a sense of community and cause among the volunteers. In larger towns, fire departments were formed and firemen hired. Following the last blaze of January 9, 1974, Helena built a fire tower and hired a watchman. Residents even convinced the Territorial Legislature to pass Montana's first fire law, taxing all Helena residents and property owners one dollar to help support a fire department.

Many technical advances have occurred during the past 100 years in community water distribution systems, firefighting equipment, warning systems, and safety gear for firefighters. At one point in time, horse-drawn water wagons with hand-operated pumps were used. Because of limited water pressure and inadequate water storage, only small fires were fought successfully. With the advent of motorized trucks, equipped with tanks and pressure pumps, firefighting capabilities were drastically improved. Over time, more efficient and more powerful pumps having the ability to shoot water long distances have been developed.

It wasn't until the late 1800's that Montana towns began to construct water supply mains equipped with fire hydrants. Although this certainly didn't end all of the problems encountered by firefighters, it did resolve the problem of hauling water in tank trucks or wagons. The best systems for firefighting were found in towns that invested in a water system.

The building of municipal water systems served a dual purpose. Municipal systems not only provided the convenience of running water to homes and businesses, but also increased fire protection for a town when fire hydrants were installed. Water towers, water mains, fire hydrants, and better fire alert systems have all contributed to improve community firefighting capabilities.

Other important technological advances came in the building materials used for construction. Most early homes and businesses were made of wood, as was true of the buildings destroyed in the severe Helena fires. Standard building and construction codes, along with the use of metal, brick, and concrete, and other less flammable construction materials have helped limit the spread of fires. The building and construction codes address such things as space requirements between residential structures and set-back (appropriate distance from roads and other structures).

Today, firefighting systems have advanced beyond the fire hydrant and the fire department. Indoor sprinkler systems are available and, in some instances, are required when building or renovating a structure. When a fire breaks out, an electronic heat or smoke sensor activates an early warning system at the fire station and starts the sprinkler system. The sprinkler system is computer operated and is sensitive enough to spray water on separate floors or in specific areas of the building where the fire occurs. There are also "mechanical" systems that are triggered by heat.

Unfortunately, not all people can afford or take advantage of the technological improvements that have occurred in firefighting. For example, many small Montana towns which do not have a water distribution system, cannot afford to build a system.

Materials

Three 5-gallon buckets or large garbage buckets
Cups (one for each student)
75-foot garden hose
Spigot
Stopwatch or watch with a second hand

Procedure

1. Explain the fundamental components of a municipal firefighting system. (A source of water, a method of storing enough water to fight a fire, a means of transporting the water to a fire, an early warning system, and people and equipment to fight the fire.) Explain that, over time, technological advances have occurred to drastically improve the ability to fight fires. Review the progression from the bucket brigade to today's sophisticated equipment.

2. Send your students to the library to locate a few photographs of some of the early fire engines. It might also be beneficial to assign a few students the task of reviewing some Montana history books for fire stories. Have the students bring the books and photographs back to class and share them with their classmates in a class discussion.

3. Have your students think about the words "public safety." What does public safety mean? (Public safety is generally defined as the right given to a political governing body [city, township, or county] to protect the public against bodily injury and property loss). Public safety is a right of all of the public and not specific groups or individuals. The level of protection is determined by the governing body, and no one member can be discriminated against or denied protection. Why do you think that municipal governments rather than private businesses operate firefighting systems? (Because fire protection is essential for all people. Even if one person doesn't want fire protection, his or her neighbors' safety should not be jeopardized by another person's indifference to a service.) What other responsibilities do communities have relating to public safety? (Water treatment and water distribution, sewage collection and disposal, solid waste collection and disposal, police protection, and public warning systems.)

4. Bucket Brigade Demonstration - Explain to your class that one of the most important advantages of our modern firefighting equipment is the large amount of water that can be sprayed on a fire in a short period of time. This demonstration will reinforce this important point. Set up the following class experiment. NOTE: This activity should be conducted outdoors, in a pool area, or in a room where it is acceptable for the floors to get wet.

    a. Divide your class into two groups.

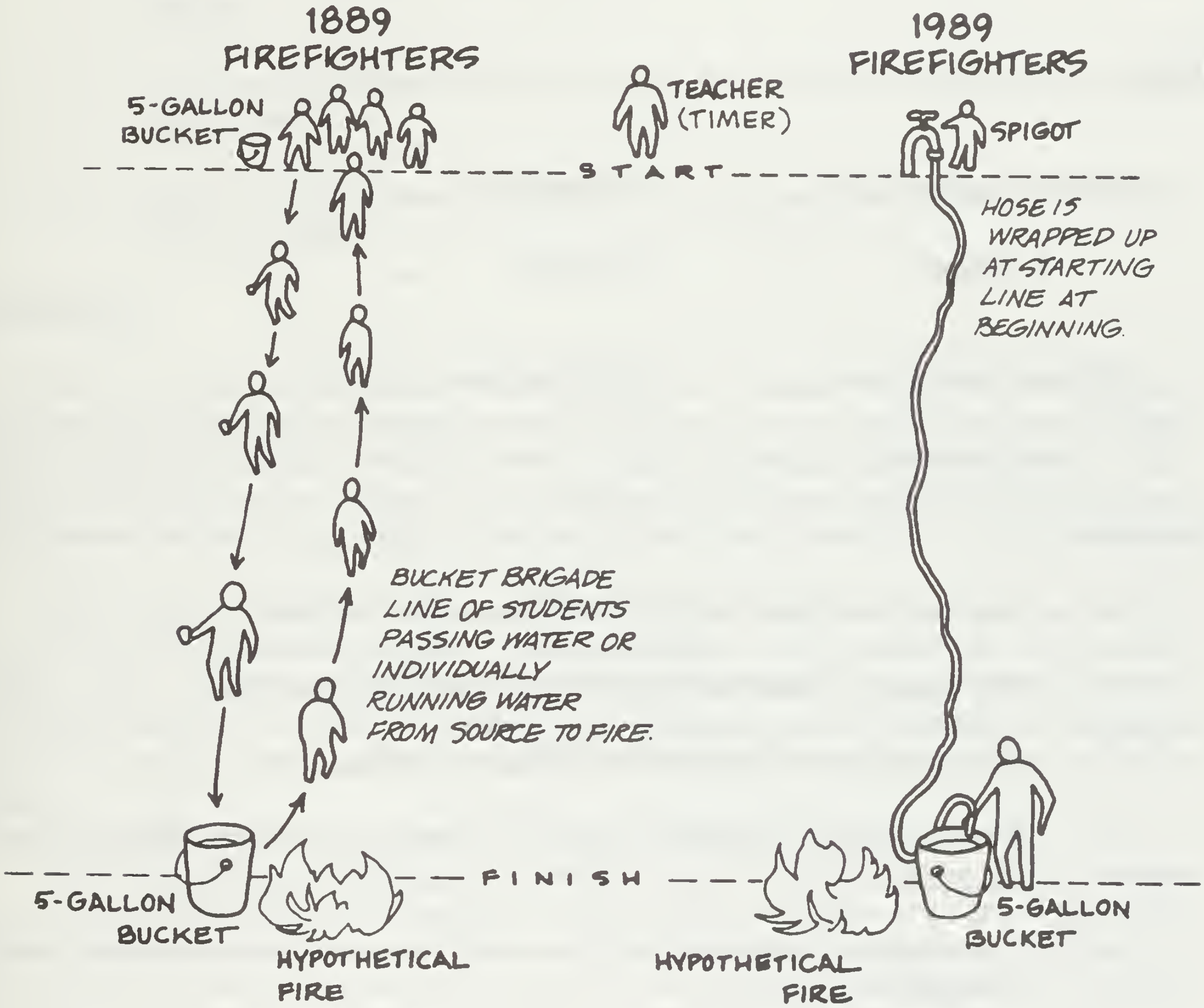
       Group 1 will be the 1990 firefighters. This group will be allowed to use the school's water system (outdoor spigot) and a garden hose to move the water to a hypothetical fire. Assign two students to this group -one to turn the water on and off and the other to run with the hose to put out the fire.
       Group 2 will be the 1890 firefighters. The rest of the students will be in this group. This group will be allowed to use cups to extinguish the fire. Each cup will be equivalent to a 5-gallon bucket of water. This group has two options for moving the water. They can individually run the water from the well (represented by a 5-gallon bucket) to the fire and then back to the well or they could form a bucket brigade.

    b. The goal of both groups is to fill the 5-gallon bucket (representing the hypothetical fire).

    c. Record: 1) the starting time and the finishing time for each group, 2) the distance traveled between the well and the fire, and 3) the number of cups hauled by the 1890 group. Note: In an attempt to avoid chaos, don't allow all of the 1890 firefighters to haul water at the same time. It is advisable to send one student or a group of two students down and back. Repeat in an orderly fashion so that all

the students have a chance to haul water.

d. Have your students answer the questions on the Bucket Brigade Worksheet during class or as a class assignment.



Extension

Invite your city's fire chief to your class to discuss the relationship between the city's fire department and the city's water department. Most fire departments are willing to give tours of their facilities and equipment.

BUCKET BRIGADE WORKSHEET

Student's Name: ______________________ *Date:* __________________________

Data

1890 a. Starting time ____ Finishing time ____

b. Distance ____ # of Cups ____

1990 a. Starting time ____ Finishing time ____

b. Distance ____

Questions

1. How long did it take the 1890 firefighters to fill the bucket?

2. How long did it take the 1990 firefighters to fill the bucket?

3. How many cups of water did the 1890 group haul?____

4. If one cup equals 5 gallons of water, how much water did the 1890 group haul? __________

5. If one gallon of water weighs 8.34 pounds, how many pounds of water did the 1890 group haul?______

6. How many gallons of water could the 1890 group haul per minute?______ Per hour?______

7. How many gallons of water could the 1990 group deliver per minute? Per hour? __________

8. How much more water did the 1990 firefighters transfer than the 1889 firefighters? Per minute?______ Per hour?______

BRIDGE OVER TROUBLED WATER

Objectives: Students will:

1) better understand the water-related transportation problems that faced early explorers and settlers as they traveled across the territory that later became Montana,

2) understand the influence that river crossings had and have on Montana's settlement patterns, and

3) learn about bridge design and construction by participating in a class bridge-building contest.

Background

Can you imagine crossing Montana from east to west or north to south in 1850? The land was untamed and relatively unchanged by man's influence. The trip would have been difficult and taken a traveler as long as a month or more. The only roads that existed were merely trails. People traveled by steamboat, railroad, and on horseback, or in wagons pulled by horses or oxen. In comparison, the same trip in 1990 by interstate highway would take about eight to ten hours.

Many hazards faced the people who traveled across the prairie. By any modern day standard, travel was extremely difficult. Natural disasters such as blizzards, heavy snows, tornadoes, floods, and drought caused the loss of property and life. Only the poorly informed or foolhardy would try to cross the prairie without taking the proper precautions. The harsh elements and lengthy delays caused by a variety of calamities could cause a journey to end in disaster.

Rivers and streams were obstacles to overland travel. Consider crossing the Yellowstone River today in an area where no bridge exists. This situation would present quite a challenge for a family in 1890 traveling in a wagon filled with all of the family's possessions. Probably one of the most formidable river crossings in Montana was the Yellowstone River. Crossing the Yellowstone River was dangerous and, at times, a life-threatening feat. The completion of railroad bridges over the Yellowstone and Missouri Rivers was a major accomplishment.

In Mrs. Frances Fuller Victor's book, "The River of the West", Victor describes the Yellowstone River crossing of a group of trappers and traders led by Jedediah Smith in 1829.

> Arrived at the Yellowstone with his company, Smith found it necessary, on account of the high water, to construct Bull-boats for the crossing. These are made by stitching together buffalo hides, stretching them over light frames, and paying the seams with elk tallow and ashes. In these light wherries the goods and people were ferried over, while the horses and mules were crossed by

swimming.

> The mode usually adopted in crossing large rivers was to spread the lodges on the ground, throwing on them the light articles, saddles, etc. A rope was then run through the pin-holes around the edge of each, when it could be drawn up like a reticule. It was then filled with the heavier camp goods, and being tightly drawn up, formed a perfect ball. A rope being tied to it, it was launched on the water, the children of the camp on top, and the women swimming after and clinging to it, while a man, who had the rope in his hand, swam ahead holding on to his horse's mane. In this way, dancing like a cork on the waves, the lodge was piloted across; and passengers as well as freight consigned, undamaged, to the opposite shore. A large camp of three hundred men, and one hundred women and children were frequently thus crossed in one hour's time."

Rivers are natural barriers to overland travel and have a damming effect on travelers. A new bridge acts like a funnel, drawing people from far and wide to the crossing. A bridge is like opening the floodgate on a dam. Once constructed, the bridge permits people to freely travel across the river. Towns like Billings, Three Forks, Great Falls, Glendive, Livingston, Havre, Kalispell, and Missoula, and many smaller towns were established at river crossings. River boats added to the prosperity in river towns. These towns were the crossroads of the prairie's early transportation network.

One way of speeding up travel and making overland travel safer was to build bridges. Most of the early bridges were constructed of wooden beams and planks. The life expectancy of many bridges was somewhat short due to the destructive forces of spring floods and floating ice. Some early wooden bridges were destroyed by prairie fires. In later years, bridges were designed and constructed with more long-lasting and durable metal and concrete materials. Even today bridges fall victim to heavy loads, spring floods, ice jams, and old age.

Materials

Map of Montana
Reference books on bridges and bridge design
Instructions for bridge building contest
Balsa wood, toothpicks or popsicle sticks
Glue: white (hot glue stick works best for quick projects)
Razor blades - craft knives and saws

Procedure

1. Have your students read the story describing Jediah Smith's trip across the Yellowstone River. Ask if any of your students have ever visited a place that did

not have roads or bridges. What types of problems did the student(s) experience? What things would a person have to take into consideration when traveling through a roadless and bridgeless area (i.e., safety, time of year, building materials, route)?

2. Have four or five students go to the library and reserve several books on bridges for reference. If your school's library does not have reference books on bridges, your students should contact the State Library. Have each student find one photograph of a bridge and bring it to class with the following information: name of bridge (if available), name of the river that the bridge crosses, span (distance across), age, and any other interesting or unique features of the bridge. Your students should find a variety of bridge designs.

3. Have your students discuss the following study questions:

   A. What effects might the building of a new bridge have on the development of a region, a city, or a section of a city? List and discuss the positive and negative impacts.

   B. Why are river crossings on Montana's major rivers usually associated with towns? Were the towns there before the river crossing or vice versa?

   C. Have each student or team of students select a site for a new bridge across the Missouri River. Discuss the rationale for choosing the site. What criteria were used to select the site?

      Include a list of the positive and negative aspects of the proposed bridge site.

      Have your class vote on the best location based on the reasons provided by their classmates.

   D. Have each student select a river or stream and then count the number of bridges that cross the river. What factors determine the number of bridges?

4. Your class will now begin a class bridge building contest. The goal of the contest is to have each student design and construct a bridge. Your students will have fun building a bridge and the competition should encourage some excellent designs. Note: There are many ways to conduct a bridge building contest. The following instructions have been proven reliable and generally produce excellent results. The winning bridge will be determined by structural efficiency. Bridge structural efficiency:

$$(E) = \frac{\text{Maximum Load Support (Grams)}}{\text{Mass of Bridge (Grams)}}$$

b. No outriggers will be allowed. Outriggers are any structure added to a bridge primarily to satisfy dimensional constraints.

c. The bridge must contain a "roadbed" with a minimum width of 50 mm (2 1/4") and a minimum length of 300 mm (12"). The top surface of the roadbed must be no more than 30 mm (1 1/4") above the top surface of the test supports. The roadbed is not to be a solid surface; it must have openings for the loading rod.

d. No portion of the unloaded bridge shall lie below the level of the test supports.

e. The unloaded bridge must be symmetrical with respect to its vertical geometric center line.

f. All construction requirements and dimensions will be checked prior to testing. Bridges which do not meet these criteria will be disqualified.

3. Loading

a. The bridge supports will be 250 mm (10") apart and the load will be applied at the center of the bridge. The location of the load will be the same for all bridges and will be determined by the judges on the day of the contest.

b. The load will be applied through a wooden block resting on the roadbed. The block will be 50 mm x 50 mm x 20 mm (2 1/4" x 2 1/4" x 7/8"). The load will be applied to the loading block by a loading rod (a 6-inch eye bolt) which will be pushed up through the bridge from below and screwed into the block. The bridge construction must accommodate all possible positions of loading block and rod; bridges which do not do so will not be able to undergo testing and will be disqualified.

4. Testing

a. The model will be centered on the supports.

b. A bucket will be attached to the rod and the load will be applied by the student adding sand to the bucket until failure occurs. Sand will be added in a continuous fashion, possibly through a large funnel. Maximum time for loading will be ten minutes.

c. Failure will be defined as the inability of the bridge to support additional load. Weigh the bucket and sand, and record the results on the board.

BRIDGE BUILDING CONTEST

Objective

The objective is to design and build the lightest possible bridge capable of supporting a given load over a given span using a given material.

Duration

Allow the students two weeks to design and construct a bridge. All bridges should be completed before the contest begins.

Instructions

1. Materials

   a. The bridge must be constructed only from 3/32 in. x 3/32 in. square balsa wood provided by the student. Toothpicks and popsicle sticks also work. Whatever material is selected should be used by all students. Balsa wood may only be modified in length (cut) with mitering of joints allowed at any angle.

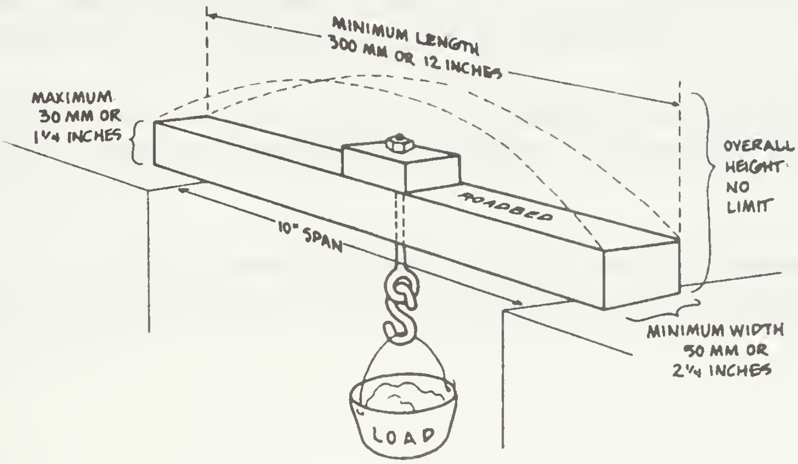
   b. Any commonly available glue may be used. It shall be supplied by the student.

   c. No other materials may be used. Do not impregnate the wood with glue. Glue must be confined to points of contact.

2. Construction

   a. The bridge dimensions must be in accordance with the following:

      1. Bridge length - minimum of 300 mm or 12 inches
      2. Bridge width - minimum of 50 mm or 2 1/4 inches
      3. No limit on height.



Judging

The contest will have two categories of winners: 1) the bridge with the highest structural efficiency, and 2) the bridge with the best design, color scheme, and artwork. Have your class vote for the bridge with the best design.

Evaluation

Road and bridge construction is an important responsibility of the government. Invite the person(s) in charge of your town's or county's road system to give a presentation on bridges and bridge construction. This person should talk about bridge safety, bridge maintenance, construction costs, and common bridge problems. This person may also be willing to help judge the bridge building contest.

I REMEMBER

Chapter Reference	: Introduction
Grades	: 4-6
Subject	: Language Arts, Social Studies
Duration	: One classroom session
Group Size	: 10-12 people per group
Key Vocabulary	: dependency, water use

Objectives:

Students will be able to:

* Improve their listening and memory skills.
* Better relate to their dependence on water.
* Discuss different kinds of water uses.

Background

Water is an important resource in Montana. Your students will have many experiences that relate to their dependence on water. Water is used for bathing, cooking, drinking, growing plants, and other uses.

Activity

This is a memory game. Ask your students to arrange themselves in a circle.

* Designate one person in the circle to start the game. The first player will complete one of the following sentences:

  Water is important to me because (I like to drink it).
  I use water to (one type of use).

* The next player repeats the first statement and adds one of his or her own. The game continues around the circle until the list is too long to remember.

* Students might also want to create a story on an experience they might have had at a vacation spot where water was the highlight of the trip. (Last summer my family and I drove to the lake to swim.)

* Another variation would be to have the students say their name and mention a profession that uses water and how the water is used. (My name is Sam, I am a firefighter and I use water to put out fires.)

Closure

After the game, list the different kinds of water uses that the students mentioned. Have the students categorize each use as essential for life (water for drinking, growing crops) or nonessential for life (washing your car, watering grass). Some of your students might suggest that all types of water uses are essential. This is a valid observation; however, point out that life will go on if the car is not washed or the lawn watered every day.

1. What makes a type of water use essential?

2. What types of water use are nonessential?

APPENDICES

Questions and Story Telling (Ice Breaker)

Project WET Water Trivia Contest (Answer Sheet Provided After Contest)

Project WET Montana Workshop Evaluation

QUESTIONS AND STORY TELLING

1. ________________ *drinks eight glasses of water every day.*
2. ________________ *owns a boat and motor.*
3. ________________ *knows how much his/her family paid for water last month.*
4. ________________ *has witched for underground water or dug a well by hand.*
5. ________________ *can tell a fish story or caught a whopper-sized fish.*
6. ________________ *has come from more than 50 miles to this workshop.*
7. ________________ *sings in the shower.*
8. ________________ *was once a lifeguard.*
9. ________________ *has hauled water with a bucket.*
10. ________________ *has eaten a goldfish.*
11. ________________ *can name a song that says something about water.*
12. ________________ *has watched a fish spawning operation.*
13. ________________ *has toured a water purification plant or waste water treatment plant.*
14. ________________ *owns a lake cottage.*
15. ________________ *did not water the lawn last summer.*
16. ________________ *has water that tastes funny.*
17. ________________ *irrigates his/her crops.*
18. ________________ *is a dust bowl baby (1930-1940).*
19. ________________ *has been in a flood.*
20. ________________ *has a water right.*
21. ________________ *leaves the water running when brushing his/her teeth.*
22. ________________ *has a fishing license in his/her billfold or purse.*

Project WET Montana Workshop Evaluation

*Workshop Location:*______________________
*Date:*_______________________________
*Instructor:*___________________________

Thank you for your interest in Project WET Montana! The sponsors and others working with Project WET Montana would like to ask your assistance in providing the following information. Your responses will help us evaluate WET's effectiveness, and improve project services. Please feel free to contact the Project WET Montana office at anytime if you have comments for improving or questions regarding WET materials. Thanks again!

Background of Respondent:

a. *Position Description/Title:*____
b. *Instruct These Courses:*____
c. *Number of Students Reached Per Year:*_____________________________________
d. *Years of Teaching Experience:*____
e. *Does your curriculum include information on water topics?*___________________
*Please list water topics you presently teach:*____________________________________

Evaluation:

a. *Did this workshop broaden your understanding of Montana's water resources and resource issues? (Yes or No) In your opinion, what was the most useful information presented at this workshop. Explain why.* ______________________
____
____
____

b. *Where workshop goals clearly stated and covered? Yes or No*

c. *This workshop was: a. excellent b. very good c. good d. Okay e. Poor*

d. *The best features of this workshop were:*______________________________
____
____

e. *Ways in which this workshop could have been improved:*____________________
____
____

f. *Any other comments, suggestions, request, and/or concerns?*________________
____
____
____

Water Words

A glossary of water-related terms

arable - Suitable for cultivation.

arid - Describes regions where precipitation is insufficient in quantity for most crops and where agriculture is impractical without irrigation.

artesian aquifer - An aquifer bounded above and below by earth materials of significantly lower permeability than the aquifer itself; contains confined or artesian water. (Also called a confined aquifer).

artesian water - Ground water under pressure greater than atmospheric pressure. (Also called confined water.)

artesian well - A well tapping an artesian aquifer. The water level in such a well rises above the artesian aquifer to a point at which the artesian pressure equals atmospheric pressure. An artesian well will flow if the artesian pressure exceeds atmospheric pressure at land surface.

atmosphere - The layer of gases surrounding the earth and composed of considerable amounts of nitrogen, hydrogen, and oxygen.

average annual damages - The average annual flood and related damages for a total period of record; measured in dollars.

average annual runoff (yield) - The average of water-year runoff for a total period of record; measured in inches or acre-feet.

average flow - The average of annual volumes converted to a rate of flow for a single year; measured in cubic feet per second (cfs).

B

bank stabilization - Implementation of structural features along a streambank to prevent or reduce bank erosion.

bank storage - The water which infiltrates the banks of a stream channel during high flows or floods, is stored there, and is released to the stream after the high water recedes.

base flood (100-year flood) - The flood having a 1 percent average probability of being equalled or exceeded in a given year at a designated location. It may occur in any year or even in successive years if the hydrologic conditions are conducive for flooding.

base flow - 1) Streamflow derived primarily from groundwater contributions to the stream. 2) As defined in the State Water Resources Act of 1971, the flows administratively established "to provide for the preservation of wildlife, fish, scenic, aesthetic and other environmental values, and navigational values."

base period - A period of time from which comparisons of other time periods are made, normally used with reference to price, population, production, or other statistics.

basin - A physiographic region bounded by a drainage divide; consists of a drainage system comprised of streams and often natural or man-made lakes. (Also called drainage basin or **watershed.**)

bed load - The larger or heavier particles of the stream load moved along the bottom of a stream by the moving water and not continuously in suspension or solution.

beneficial use - Any water use which enables the user to derive economic or other benefit from such use. State law defines beneficial use as the "use of water for a purpose consistent with the best interests of the people of the state."

benefit-cost ratio - The relationship of the economic benefits of an action to its costs.

benthic region - The bottom of a body of water, supporting the benthos.

benthos - All the plant and animals living on or closely associated with the bottom of a body of water.

best management practices - Accepted methods for controlling non-point source pollution; may include one or more conservation practices.

biochemical oxygen demand (BOD) - A measure of the amount of oxygen removed from aquatic environments by aerobic microorganisms for their metabolic requirements. Measurement of BOD is used to determine the level of organic pollution of a stream or lake.

biological community - All of the living things in a given environment.

biome - An extensive community of plants and animals whose composition is determined by soil and climate.

biota - The plant and animal life of a region.

boiling point - The temperature at which a liquid boils. For water, it is 212° Fahrenheit (F) or 100° Celsius (C) at sea level. The boiling point of water decreases with elevation.

buried drain - A covered drain usually made of clay, concrete, or plastic pipe installed beneath the ground surface at a planned grade and depth.

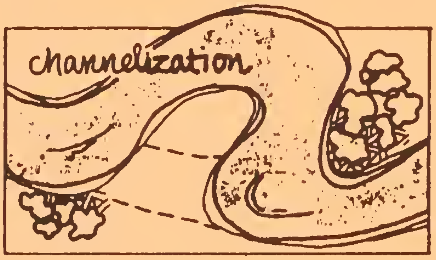
capacity (fish and wildlife) - An estimate of the number of hunter-days or fisherman-days which are available for use when all habitat is utilized at an optimum level.

capillary action - The action by which water is drawn around soil particles because there is a stronger attraction between the soil particles and the water molecules themselves.

carrying capacity (economic) - The level of production of goods and services which can be sustained by a resource base.

carrying capacity (environmental) - The number and type of species which a particular habitat can sustain.

channelization - The artificial enlargement or realignment of a stream channel.



chemical oxygen demand (COD) - A measure of the amount of oxygen needed to oxidize organic and in-organic material present in water or sediment; a measure of the organic and in-organic pollutant level of sewage and industrial waste water.

cirrus - A principal cloud type found at high altitudes and composed of ice crystals collected into delicate wisps or patches.

climate - Meteorological elements that characterize the average and extreme conditions of the atmosphere over a long period of time at any one place or region of the earth's surface.

closed basin - A drainage basin having no natural outlet.

cloud - A visible mass of minute water and/or ice particles in the atmosphere above the earth's surface.

cloud seeding - Any process of injecting a substance into a cloud for the purpose of influencing the cloud's subsequent development. Ordinarily, this refers to the injection of a nucleating agent, which creates a nucleus around which precipitation will form.

coal slurry pipeline - A pipeline which transports pulverized coal suspended in liquid, usually water.

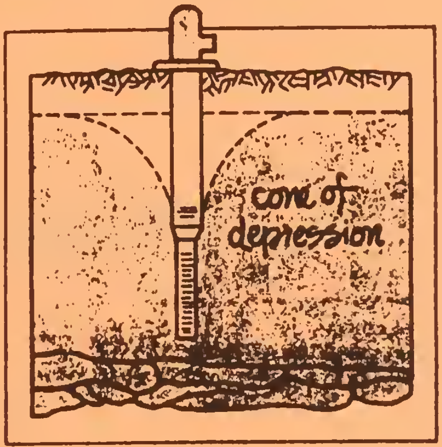
coliform bacteria - A group of organisms usually found in the colons of animals and humans. The presence of coliform bacteria in water is an indicator of possible pollution by fecal material.

compact - An agreement between certain states, individuals, etc. concerning their mutual water interests.

condensation - The process by which a vapor becomes a liquid or solid; the opposite of evaporation. In meteorological usage, this term is applied only to the transformation from vapor to liquid.

conditional water permit - An authorization for the permittee to construct any facilities (such as a well and irrigation system) and to begin utilization of the water. A water right and a water permit are not the same thing. See **water right**.

cone of depression - A cone-shaped depression defining the area of influence of a pumping well in the potentiometric surface of an aquifer.



confluence - The place where streams meet.

conjunctive use - Planned management of surface water and ground-water resources as an inter-related system.

conservation - The continuing protection and management of natural resources in accordance with principles that assure their optimum long-term economic and social benefits.

conservation storage - The portion of water stored in a reservoir that can be later released for useful purposes such as municipal water supply, power, or irrigation. Conservation storage is the volume of water stored between dead reservoir storage and flood control storage.

conservation tillage - A level of reduced tillage combined with one or more soil and water conservation practices.

consumptive use - The difference between the total quantity of water withdrawn from a source for any use and the quantity of water returned to the source (e.g., the release of water into the atmosphere; the consumption of water by man, animals, and plants; and the incorporation of water into the products of industrial or food processing).

continental divide - A drainage divide separating the rivers which flow toward opposite sides of a continent.

contributing area - That portion of a watershed which contributes to measured runoff under normal conditions.

cost allocation - The procedure for dividing total financial cost among the benefiting parties.

cost-sharing - The procedure for implementing the cost allocation in a legally binding agreement between or among the participants.

creek - A small stream of water which serves as the natural drainage course for a drainage basin. The term is relative according to size. Some creeks in a humid region would be called rivers if they occurred in an arid area.

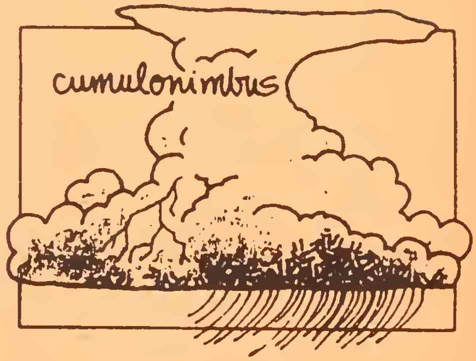
crest - 1) The top of a dam, dike, or spillway. 2) The highest elevation reached by floodwaters flowing in a channel.

croplands - Land currently tilled, including cropland harvested, land on which crops have failed, summer fallowed land, idle cropland, cropland planted in cover crops or soil improvement crops not harvested or pastured, rotation pasture, and cropland being prepared for crops, or newly seeded cropland. Cropland also includes land planted to vegetables and fruits, including those grown on farms for home use. All tame hay is included as cropland. Wild hay is excluded from cropland and included in pasture and range.

cubic feet per second (cfs) - A unit expressing rate of discharge, typically used in measuring streamflow. One cubic foot per second is equal to the discharge in a stream of a cross section one foot wide and one foot deep, flowing with an average velocity of one foot per second; equals 448.8 gallons per minute.

cultural landscape - Man-made features of a region reflecting land-use patterns, population distribution, and other activities of man that have altered the natural landscape.

cumulonimbus - (Commonly called thundercloud, thunderhead, thunderstorm.) A principal cloud type; the ultimate stage of development of cumulus clouds. Cumulonimbus clouds are very dense and very tall, commonly 5 to 10 miles in diameter, and sometimes reaching heights of 12 miles or more. The upper portion is at least partly composed of ice crystals, and it often takes the form of an anvil or vast plume. The base of the cloud is invariably dark and is often accompanied by low, ragged clouds.



cumulus - A principal cloud type characterized by vertical development; usually isolated with a dark, nearly horizontal base and upper parts resembling domes or towers.

current - The portion of a stream or body of water which is moving with a velocity much greater than the average of the rest of the water.

dam - A structure of earth, rock, concrete, or other materials designated to retain water, creating a pond, lake, or reservoir.

dead reservoir storage - The volume of water in a reservoir stored below the lowest outlet or operating level.

degradation (river beds) - The general lowering of the streambed by erosive processes, such as scouring by flowing water.

demand - 1) The numerical expression of the desire for goods and services associated with an economic standard for their attainment. 2) The requirement of a particular user group.

demography - The statistical science dealing with the distribution, density, vital statistics, etc. of population.

dendritic - A drainage pattern in which tributaries branch irregularly in all directions from and at almost any angle to a larger stream. From an aerial view, it resembles the branching pattern of trees.

depletion - Loss of water from surface water reservoirs or ground-water aquifers at a rate greater than that of recharge.

detention dam - An artificial barrier commonly used for temporarily impounding water. (Also called retention dam.)

dew - The droplets of water condensed from air onto warm surfaces when the temperature falls.

dew point - The temperature at which a gas or vapor condenses to form a liquid; the point at which dew beings to form.

dike - An embankment to confine or control water. See **levee**.

discharge - In the simplest form, discharge means outflow of water. The use of this term is not restricted as to course or location and it can be used to describe the flow of water from a pipe or from a drainage basin. Other words related to it are runoff, streamflow, and yield.

dissolve - A condition where solid particles mix, molecule by molecule, with a liquid and appear to become part of the liquid.

dissolved oxygen (DO) - The amount of oxygen freely available in water and necessary for aquatic life and the oxidation of organic materials.

disposal system - A system for the disposing of wastes, either by surface or underground methods; includes sewer systems, treatment works, disposal wells, and other systems.

diversion - The transfer of water from a stream, lake, aquifer, or other source of water by a canal, pipe, well, or other conduit to another watercourse or to the land, as in the case of an irrigation system.

diversion dam - An artificial barrier designed to enable the transfer of water from a stream into a canal, pipe, or other conveyance mechanism.

domestic consumption (use) - The quantity of water used for house-hold purposes such as washing, food preparation, and bathing.

drainage area - The land area contributing runoff to a stream or other body of water, and generally defined in terms of acres or square miles.

drainage divide - A natural ridge on the land surface which divides one drainage area from another.

drainage lateral - A side ditch or conduit which contributes water to a drainage main.

drainage main - A natural or artificial ditch or conduit for moving water off the land.

drilling mud - A mixture of clay, water, and other materials commonly used in drilling with a rotary drill rig. The mud is pumped down the drill pipe and through a drill bit and back up to the surface between the drill pipe and the walls of the hole. The mud helps lubricate and cool the drill bit as well as carry the cuttings to the surface. The mud also stabilizes the hole.

dry dam - A dam that has an outlet positioned so that essentially all stored water will be drained from the reservoir by gravity. The reservoir will normally be dry.

E

easement - A legal instrument enabling the giving, selling, or taking of certain land or water rights without transfer of title, such as for the passage of utility lines.

ecology - The study of the inter-relationships of living things to one another and to the environment.

ecosystem - A community of animals, plants, and bacteria, and its interrelated physical and chemical environment.

effluent - The sewage or industrial liquid waste which is released into natural waters by sewage treatment plants, industry, or septic tanks.

endangered species - Any plant or animal species on the verge of extinction throughout all or a significant area of its range; identified by the Secretary of Interior as "endangered," in accordance with the 1973 Endangered Species Act.

energy - The capacity to perform work, or the potential for power and activity; energy may be captured or held in living matter (e.g., food is stored energy).

enhancement - Emphasis on improving the value of particular aspects of water and related land resources.

environment - All of the external factors, conditions, and influences which affect an organism or a community.

environmental impact statement (EIS) - A required evaluation of the effects of actions or programs on the natural environment. The National Environmental Policy Act of 1969 requires, in some circumstances, that a federal EIS be prepared.

ephemeral stream - A stream which carries only surface runoff and thus flows only during and following precipitation in the immediate area.

erosion - The wearing down or washing away of the soil and land surface by the action of water, wind, or ice.

eurythermic - Capable of tolerating a wide range in temperature.

eutrophication - The natural process by which lakes and ponds become enriched with dissolved nutrients, resulting in increased growth of algae and other microscopic plants.

evaporation - The process by which a liquid changes to vapor.

evapotranspiration - The loss of water from a land area through evaporation from the soil, and through plant transpiration.

fauna - The entire animal population of a specific region and/or time.

feasibility study - A complete assessment of alternative courses of action to solve one or more problems, to meet needs, and to recommend the most practical course of action consistent with state and local planning objectives.

flood - The temporary inundation of normally dry land areas resulting from the overtopping of the natural or artificial confines of a river or other body of water.

flood control - The prevention or reduction of flood damages by structural and nonstructural measures.

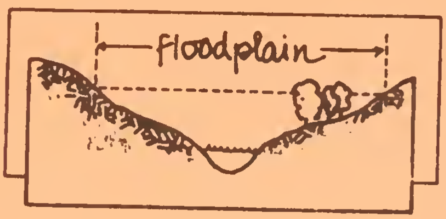
flood control storage - Storage of water in reservoirs to reduce flood damage.

flood damage - The economic loss caused by floods including damage by inundation, erosion, or sediment deposition. Damages also include emergency costs and business or financial losses. Evaluation may be based on the cost of replacing, repairing, or rehabilitating; or the comparative change in market or sales value; or on the change in income or production caused by flooding.

flood frequency - An expression or measure of how often a hydrologic event of a given size or magnitude should, on an average, be equalled or exceeded. For example, a 50-year frequency flood (2 percent chance) should be equalled or exceeded, on the average, once in 50 years.

flood peak - The highest magnitude of the stage or discharge attained by a flood (also called peak stage or peak discharge).

floodplain - Any normally dry land area that is susceptible to being inundated by water from any natural source. This area is usually lowland adjacent to a stream or lake.



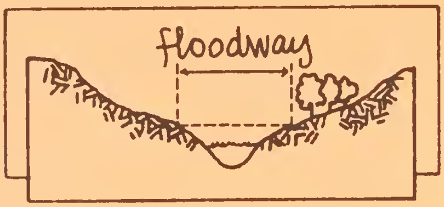
floodplain management - The operation of a program of corrective and preventive measures for reducing flood damage, including but not limited to, flood control projects, floodplain land use regulations, floodproofing of buildings, and emergency preparedness plans.

flood probability - The statistical probability that a flood of a given size will be equalled or exceeded in a given period of time.

floodproofing - Any combination of structural and nonstructural additions, changes, or adjustments to structures which reduce or eliminate flood damage.

flood stage - The stage at which overflow of a stream or body of water begins.

floodway - The channel of a river or stream and those parts of the adjacent floodplain adjoining the channel which are required to carry and discharge the base flood.



flora - The entire plant population of a specified region and/or time.

flow - The rate of water discharged from a source; expressed in volume with respect to time.

flow augmentation - The addition of water to a stream especially to meet instream flow needs.

flowing well - A well that yields water at the land surface without pumps or other means of raising water to the land surface. See **artesian well.**

fossil fuels - Hydrocarbons such as natural gas, petroleum, oil, coal, or any fuel derived from such materials for the purpose of creating heat or power.

freeboard - The vertical distance between a designed maximum water level and the top of a structure.

free-flowing - Without artificial restrictions.

G

gaging station - A particular site on a stream, canal, lake, or reservoir where hydrologic data is collected.

gallon - A unit of volume. A U.S. gallon contains 231 cubic inches, 0.133 cubic feet, or 3.785 liters. One U.S. gallon of water weighs 8.3 pounds.

gallons per minute - A unit expressing rate of discharge, typically used in measuring well capacity.

gasification - The process of combining coal with air (or pure oxygen) and stream to yield a gaseous product suitable for use either as a direct source of energy or as a raw material used in the synthesis of chemicals, liquid fuels, or other gaseous fuels.

geology - The science that studies the physical nature and history of the earth.

geothermal energy - Energy that can be extracted from the earth's internal heat, such as naturally occurring warm or hot ground water found in the earth's crust.

glacial drift - All earth material transported and deposited by the ice and/or by water flowing from a glacier.

glacial outwash - Stratified material, chiefly sand and gravel deposited by meltwater streams in front of the margin of a glacier.

glacial till - All earth material deposited directly by a glacier with little or no stratification or reworking by meltwater.

glacier - A huge mass of ice, formed on land by the compaction and re-crystallization of snow, that moves very slowly downslope or outward due to its own weight.

gradient - Degree of incline; the steepness of a slope.

gram - The basic unit of weight in the metric system equal to 1/28th of an ounce or .0022046 pound.

grassed waterway or outlet - A natural or constructed waterway, usually broad and shallow and covered with erosion-resistant grasses, suitable to resist potential damages resulting from runoff.

ground water - Subsurface water found in the zone of saturation.

ground-water overdraft - The portion of ground-water withdrawals that exceeds recharge; sometimes called ground-water mining.

ground-water recharge - The inflow to an aquifer.

growing season - The number of consecutive days having a minimum temperature above 32°F.

H

habitat - The native environment where a plant or animal naturally grows or lives.

hail - Precipitation which forms into balls or lumps of ice over 0.2 inch in diameter. Hail is formed by alternate freezing and melting as it is carried up and down by turbulent air currents within a cloud.

hail suppression - Any method of reducing the damaging effects of hailstorms by modifying the characteristics of the hail-producing cloud. The currently prevailing hypothesis is that silver iodide seeding provides more hailstone nuclei (and, at the same time, reduces the amount of supercooled water available to build up large hailstones) with the net effect that the hail that reaches the ground is smaller and less damaging, and also has a high probability of melting before reaching the ground.

headwaters - The source and upper reaches of a stream; also the upper reaches of a reservoir.

holistic wildlife management - A system that considers all species, as opposed to the featured species concept which selects only a few species for management.

hummock - A small but steep, irregular hill rising above the general level of the surrounding land.

hunter day - Any part of a day spent hunting by an individual.

hunter days capacity - The total annual hunter days a resource area will provide at a specified level of management.

hydraulics - The study of liquids, particularly water, under all conditions of rest and motion.

hydric soil - A soil that, in its undrained condition, is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation.

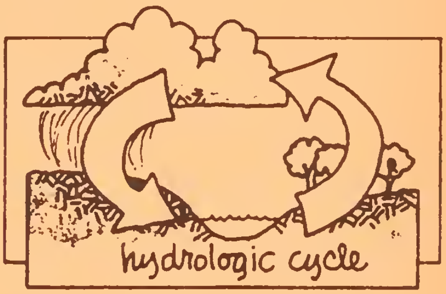
hydroelectric plant (conventional) - A hydroelectric power plant which utilizes streamflow only once as the water passes downstream.

hydroelectric plant (pumped storage) - A hydroelectric power plant which generates electric power during peak load periods by using water pumped into a storage reservoir during off-peak periods.

hydroelectricity - Electric energy produced by water-powered turbine generators.

hydrograph - A graph showing the changes in discharge of a stream or river, or the changes in water levels of a well with the passage of time.

hydrologic cycle - The constant circulation of water from the sea, through the atmosphere, to the land, and back to the sea by over-land, subterranean, and atmospheric routes.



hydrology - The science of waters of the earth; water's properties, circulation, principles, and distribution.

hydrophyte - Any plant growing only in water or very wet earth, requiring large quantities of water for growth.

hypolimnetic discharge - The process of removing nutrient-rich, oxygen-deficient water from the bottom of a lake or reservoir to improve water quality conditions.

hypolimnion - The lowermost, non-circulating layer of cold water in a thermally stratified lake; usually deficient of oxygen.

impervious - Incapable of being penetrated by water.

indigenous - Existing, growing, or produced naturally in a region.

industrial water supply - See **self-supplied industrial water.**

infiltration - The movement of water into soil or porous rock. Infiltration occurs as water flows through the larger pores of rock or between soil particles under the influence of gravity, or as a gradual wetting of small particles by capillary action.

influent stream - A stream that contributes water to the zone of saturation and to bank storage.

instream flows (fish and wildlife) - The minimum amount of water required in a stream to maintain the existing aquatic resources and associated wildlife and riparian habitat.

instream use - Uses of water within the stream channel (e.g., fish and other aquatic life, recreation, navigation, and hydroelectric power production).

interbasin transfer - The diversion of water from one drainage basin to one or more other drainage basins.

intermittent stream - A stream or reach of a stream that flows only at certain times of the year because losses from seepage or evaporation are greater than the available streamflow.

intrabasin transfer - The diversion of water within a drainage basin.

irrigable land - Land possessing favorable soil, topographic, drainage, and climatic conditions, and an adequate water supply capable of economically supporting irrigation.

irrigation - The controlled application of water to cropland, hayland, and/or pasture to supplement that supplied through nature.

irrigation efficiency - The ratio of the consumptive use of applied irrigation water to the total amount of water applied; expressed as a percentage.

irrigation return flow - Nonconsumptive irrigation water returned to a surface or ground-water supply. In cases of water rights litigation, the definition may be restricted to measurable water returning to the stream from which it was diverted.

jetty - A structure extending into a sea, lake, or river to influence the current or tide, in order to protect harbors, shores, and banks.

K

kilowatt (KW) - A unit of electrical power equal to 1,000 watts or 1.341 horsepower.

kilowatt hour (KWH) - One kilowatt of power applied for one hour.

L

lake - Any inland body of standing water, usually freshwater, larger than a pool or pond; a body of water filling a depression in the earth's surface.

land subsidence - The sinking or settling of land to a lower level.

land treatment measures - The application of vegetative tillage, structural and land management measures, individually or in combination, to alter runoff, to reduce erosion and sediment production, to increase fertility, and to improve drainage and irrigation applications.

leaching - The removal of soluble organic and inorganic substances from the topsoil downward by the action of percolating water.

left or right bank - The left- or right-hand bank of a stream when the observer faces downstream.

lentic - Characterizing aquatic communities found in standing water.

levee - See **dike**.

limnology - The branch of hydrology pertaining to the study of freshwater, especially ponds and lakes.

lined waterway or outlet - A waterway or outlet with an erosion-resistant lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to a designed height.

liquefaction - The conversion of coal into liquid hydrocarbon products.

liter - The basic unit of measurement for volume in the metric system; equal to 61.025 cubic inches or 1.0567 liquid quarts.

littoral - The region along the shore.

lotic environment - Characterizing aquatic communities found in running water.

low-level drawdown - A discharge feature of a dam allowing water to be removed from the bottom of a reservoir.

M

maximum probable flood - The largest flood for which there is any reasonable expectancy.

mean sea level (MSL) - The level of the surface of the sea between mean high and mean low tide; used as a reference point for measuring elevations.

meander line - A line delineated by government survey for the purpose of defining the bends or windings of the banks of a stream or the shore of a body of water, and as a means for ascertaining the quantity of land embraced by the survey.

megawatt - A unit of electricity equivalent to 1,000 kilowatts.

milligram (mg) - One-thousandth of a gram.

mineral resource - Known mineral deposits of an area which have present or future utility.

minimum tillage - A level of reduced tillage.

mitigation - An action designed to lessen or reduce adverse impacts; frequently used in the context of environmental assessment.

model - A simulation, by descriptive, statistical, or other means, of a process or thing that is difficult or impossible to observe directly.

mouth of stream - The point of discharge of a stream into another stream, a lake, or the sea.

multiple-purpose reservoir - A reservoir planned and constructed to provide water for more than one purpose.

mulching - The use of plant residues or other suitable materials on the soil surface, primarily to prevent evaporation of water and erosion of soil.

municipal-industrial water - Water supplied for municipal and industrial uses provided through a municipal distribution system.

N

natural flow - The flow of a stream as it would be if unaltered by upstream diversion, storage, import, export, or change in upstream consumptive use caused by development.

need - The portion of present or anticipated demand not met by current or projected supply.

net reservoir evaporation - The evaporation from a reservoir after making allowance for precipitation on the reservoir and for runoff that would have occurred if the land area were not covered by the reservoir.

nimbus - A rain-producing cloud.

nonconsumptive use - Using non-diverted water in a way that does not reduce the supply, or using diverted water and returning it to the source without reducing the supply.

noncontributing area - An area within a drainage basin having no direct connection with the basin's principal drainage system.

nonpoint source pollution - Pollution discharged over a wide land area, not from one specific location.

nonstructural measures - Managing, using, or controlling water and related lands to achieve a desired objective without structural development. Such measures have been broadly defined to include best management practices, flood warning systems, education and legal restraints such as floodplain zoning.

no-till farming - Misnomer for **minimum tillage**.

nutrients - Elements or compounds essential to life, including carbon, oxygen, nitrogen, phosphorus, and many others.

observation well - A well used to monitor changes in water levels of an aquifer and to obtain samples for water quality analyses.

offstream use - Water withdrawn from a surface water source for uses such as irrigation, municipal water supply, steam electric generation, etc.

OM&R - Operation, maintenance, and replacement of a project.

organic matter - Plant and animal residues, or substances made by living organisms.

parts per million (PPM) - The number of "parts" by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations. Large concentrations are expressed in percentages.

polychlorinated biphenyls (PCBs) - A group of toxic chemicals found in industrial wastes.

peak load - The maximum amount of electrical power delivered to a given point during a stated period of time.

penstock - A gate or sluice used in controlling the flow of water, a tube or trough for carrying water to a water wheel, or a pipe carrying water to an electric turbine.

percolation - The movement of water downward through the sub-surface to the zone of saturation.

perennial stream - A stream that flows from source to mouth throughout the year.

perfected water permit - A permit issued after the permittee has initiated beneficial use of water in accordance with the terms and conditions of the conditional water permit. The perfected water permit is the instrument of conveyance of a water right.

permeability - The capacity of porous rock, sediment, or soil to transmit water.

pH - An expression of both acidity and alkalinity on a scale of 0-14, with 7 representing neutrality; numbers less than 7 indicate increasing acidity and numbers greater than 7 indicate increasing alkalinity.

physical landscape - Natural land forms and associated natural phenomena of a region.

phytoplankton - Usually microscopic aquatic plants (sometimes consisting of only one cell).

plan - A compilation of goals and objectives, policy statements, and implementation strategies for guiding the physical, social, and/or economic development of an area or region; may be comprehensive or may relate to a specific resource.

planning - A comprehensive study of present trends and of probable future developments, together with recommendations of policies to be pursued. Planning embraces such subjects as population growth and distribution; social forces; availability of land, water, minerals, and other natural resources; technological progress; and probable future revenues, expenditures, and financial policies. Planning must be responsive to rapidly changing conditions.

point source pollution - Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers of various types.

pollution - Any alteration in the character or quality of the environment which renders it unfit or less suited for certain uses. See **water contamination** and **water pollution**.

porosity - The ratio (usually expressed as a percentage) of the volume of openings in a rock to the total volume of the rock.

potable - Water fit for human consumption.

potential supply - That part of the resource base that has the potential for development or further expansion.

potentiometric surface - An imaginary surface defined by the level to which water will rise in a well. The water table is a particular potentiometric surface.

precipitation - Water falling, in a liquid or solid state, from the atmosphere to a land or water surface.

primary waste treatment - The removal of suspended and floatable solids which will settle out of sewage and industrial wastes. Primary treatment plants generally remove 25 to 35 percent of the biological oxygen demand and 45 to 65 percent of the total suspended matter.

primary drinking water standards - Enforceable standards related directly to the safety of drinking water; set by the U.S. Environmental Protection Agency.

R

rain - Water falling to earth in drops that have been condensed from moisture in the atmosphere.

reach - Any arbitrarily defined length of a stream.

recessional moraine - Glacial till occurring as ridges where the front of a retreating glacier temporarily held a fixed position.

recharge - The processes involved in the addition of water to the zone of saturation; also the amount of water added.

reduced tillage - See **minimum tillage**.

relative humidity - The ratio expressed as a percentage of the quantity of water vapor in the air compared to the quantity of water vapor the air could hold at that temperature.

reservoir - A pond, lake, or basin (natural or artificial) that stores, regulates, or controls water.

rill erosion - The removal of rock and soil material by numerous, small, closely spaced streamlets.

riparian areas - Land areas directly influenced by a body of water. Usually have visible vegetation or physical characteristics showing this water influence. Stream sides, lake borders, and marshes are typical riparian areas.

riparian doctrine - The doctrine under which the owner of land next to a stream has certain rights to the flow of the water.

riprap - A facing layer (protective cover) of stones placed to prevent the erosion or the sloughing of a structure or embankments.

river - A natural stream of water of substantial volume.

river basin - A term used to designate the area drained by a river and its tributaries.

runoff - The amount of precipitation appearing in surface streams, rivers, and lakes; defined as the depth to which a drainage area would be covered if all of the runoff for a given period of time were uniformly distributed over it.

rural-domestic water - Household use and livestock watering associated with ranch and farm operations, and uses by the rural non-farm population.

S

saline seeps - Wet areas in non-irrigated soils where soluble salts accumulate from the evaporation of the seeping water.

salinity - The concentration of dissolved salts in water.

secondary waste treatment - Treatment (following primary treatment) which generally removes 80 to 95 percent of the BOD and suspended matter.

secondary drinking water standards - Non-enforceable standards related to the aesthetic quality of drinking water; set by the U.S. Environmental Protection Agency.

sediment - Fragmented organic or inorganic material derived from the weathering of soil, alluvial, and rock materials; removed by erosion and transported by water, wind, ice, and gravity.

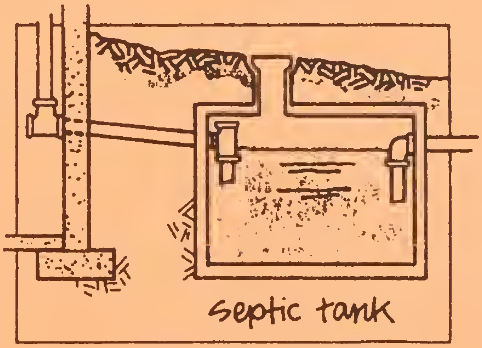
sedimentation - The deposition of sediment from a state of suspension in water or air.

sediment storage (reservoir) - That portion of total reservoir storage dedicated for sediment deposition and encroachment. Normally a part of dead storage.

self-supplied industrial water - Water for industrial use, supplied from sources other than municipal distribution systems.

sensitive species - Those plant or animal species susceptible or vulnerable to activity impacts or habitat alterations.

septic tanks - Tanks used to hold domestic wastes when a sewer line is not available to carry them to a treatment plant; part of a rural on-site sewage treatment system.



sewage system - Pipelines or conduits, pumping stations, force mains, and all other structures, devices, and facilities used for collecting or conducting wastes to a point for treatment or disposal.

sheet erosion - The removal of thin, fairly uniform layers of surface material from gently sloping land by rainfall and runoff water acting in continuous sheets of water.

sheet flow - An overland flow or downslope movement of water taking the form of a thin, continuous film over relatively smooth soil or rock surfaces and not concentrated into channels larger than rills.

silt - Sedimentary particles smaller than sand particles, but larger than clay particles.

snow density - The ratio of the volume of meltwater (derived from a sample of snow) to the initial volume of the sample.

snowpack - The winter accumulation of snow; measured in inches.

spillway - A type of structure which conveys water released from a reservoir.

spring - A spring where ground water flows naturally onto the land surface.

stage - The height of a water surface above some established reference point.

stratification - The forming or arrangement of layers.

stratum - A horizontal layer or section.

stratus - A low altitude cloud typically resembling a horizontal layer of fog.

stream - Any body of running water moving under gravity flow through clearly defined natural channels to progressively lower levels.

streambank erosion - The wearing away of streambanks by flowing water.

streambank erosion damage - Value of land areas destroyed, reduced value of land due to threat of future erosion, and the destruction or damage of wildlife habitat, buildings, bridges, utilities, or other structures.

streamflow - The discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream. The term "streamflow" is more general than the term "runoff," as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

stream load - All the material transported by a stream either as visible sediment (bed load and suspended load) or in solution (dissolved load).

stubble mulching - The management of plant residues by harvesting, tilling, planting, and cultivating in such a way so as to keep protective amounts of vegetation on the soil surface.

subbasin - Subdivision of a major river basin, drained by tributaries or groups of tributaries, including associated closed basins.

sublimation - The transition of a substance from the solid phase directly to the vapor phase, or vice versa, without passing through an intermediate liquid phase.

supercooled water - Water cooled below its freezing point without causing solidification.

suspended solids (SS) - Defined in waste management, these are small particles of solid pollutants that resist separation by conventional methods. SS (along with BOD) is a measurement of water quality and an indicator of treatment plant efficiency.

synecology - The study of different natural communities or ecosystems.

temperature - The degree of hotness or coldness.

terrestrial - Living or growing on land rather than in water or air.

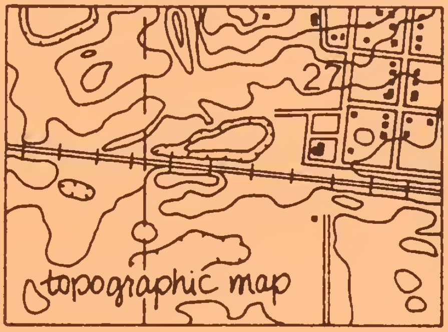
tertiary waste treatment - Selected biological, physical, and chemical separation processes to remove organic and inorganic substances that resist conventional treatment practices.

thermal pollution - The impairment of water quality through temperature increase; usually occurs as a result of industrial cooling water discharges.

threatened species - Any plant or animal species likely to become an "endangered" species throughout all or a significant area of its range; identified by the Secretary of Interior as "threatened," in accordance with the 1973 Endangered Species Act.

till - See **glacial till.**

topographic maps - Maps with lines showing equal elevation of a region's relief; also showing natural and man-made surface features, including hills, valleys, rivers, and lakes; and man-made features such as canals, bridges, roads, cities, etc.



topography - The general configuration of the land surface including relief and position of natural and man-made features.

total dissolved solids (TDS) - The quantity of dissolved materials in the water.

total storage (reservoir) - The volume of storage below the maximum designed water surface level, including dead storage.

total suspended solids - Solids, found in waste water or in a stream, which can be removed by filtration. The origin of suspended matter may be man-made wastes or natural sources such as silt.

toxin - Any of a variety of unstable, poisonous compounds produced by some microorganisms and causing certain diseases.

transpiration - The process by which water absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface, principally from the leaves.

treaty - A formal agreement between two nations.

tributary - A stream that contributes its water to another stream or body of water.

turbidity - Cloudiness caused by the presence of suspended solids in water; an indicator of water quality.

U

unconfined aquifer - An aquifer in which the upper boundary is the top of the zone of saturation (water table).

unconsolidated deposits - Sediment not cemented together, may consist of sand, silt, or clay.

unsaturated zone - The subsurface zone between the water table (zone of saturation) and the land surface where some of the spaces between the soil particles are filled with air.

V

vadose water - Water occurring in the zone of aeration between the land surface and the water table.

vested rights - A person's absolute rights which are not subject to defeat or cancellation by the act of any other person.

W

waste water - Water that carries wastes from homes, businesses, and industries; a mixture of water and dissolved or suspended solids.

waste water treatment - Any of the mechanical or chemical processes used to modify the quality of waste water in order to make it more compatible or acceptable to man and his environment.

water (H_2O) - An odorless, tasteless, colorless liquid formed by a combination of hydrogen and oxygen; forms streams, lakes, and seas, and is a major constituent of all living matter.

water budget - An accounting of the inflows and outflows of water to and from a system.

water conservation - The care, preservation, or protection of water resources.

water contamination - Impairment of water quality to a degree which reduces the usability of the water for ordinary purposes, or which creates a hazard to public health through poisoning or spread of disease.

water equivalent - The depth or amount of water that would result from the complete melting of a sample of deposited snow.

water permit - See **conditional water permit** and **perfected water permit**.

water pollution - Industrial and institutional wastes, and other harmful or objectionable material in sufficient quantities to result in a measurable degradation of the water quality.

water quality - A term used to describe the chemical, physical, and biological characteristics of water with respect to its suitability for a particular use.

water quality standard - Recommended or enforceable maximum contaminant levels of chemical parameters (e.g., BOD, TDS, iron, arsenic, and others) of water. These parameters are established for water used by municipalities, industries, agriculture, and recreation.

water resource district - A legal entity established by state statute to facilitate local administration in all phases of water development, utilization, and control.

water right - A legal right to use a specified amount of water for beneficial purposes.

watershed - Area of land that contributes surface runoff to a given point in a drainage system.

water table - The top of the zone of saturation.

water table aquifer - See **unconfined aquifer**.

water year - The 12-month period October 1st through September 30th, and designated by the calendar year in which it ends.

water yield - The surface runoff from a drainage basin; precipitation minus the evapotranspiration; usually measured in cubic feet per second or acre-feet per square mile. For ground water, the volume of water pumped from a well in a given period of time; usually measured in gallons per minute (gpm).

weather - The composite condition of the near earth atmosphere, which includes temperature, barometric pressure, wind, humidity, clouds, and precipitation. Weather variations over a long period create the climate.

weather modification - The intentional or inadvertent alteration of clouds for the benefit of man.

well - A pit, hole, or shaft sunk into the earth to tap an underground source of water.

wetlands - Lands where water saturation is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the surrounding environment. Other common names for wetlands are sloughs, ponds, and marshes.

winter kill - The complete or partial kill of the fish population in a body of water, usually occurring during prolonged periods of ice and snow cover. The kill can be attributed to a number of circumstances including diminished dissolved oxygen due to a lack of photosynthesis; the depletion of dissolved oxygen by decomposing organic matter; the production of harmful chemicals (e.g., ammonia, hydrogen sulfide, and ethanes) resulting from anaerobic decomposition; and the harmful influence of insecticides and herbicides.

withdrawal - The act of removing water from surface or ground water sources in order to use it.

zone of aeration - A subsurface zone which contains vadose water. The bottom of the zone of aeration is the water table; the top is the land surface.

zone of saturation - A subsurface zone in which all the pores of the material are filled with ground water under pressure greater than atmospheric pressure.